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SUBJECT: Correction to Final Summary Report for Contract DA-36-038-ORD-14091 - Heintz Manufacturing Company

TO: Armed Services Technical Information Agency
Document Service Center
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Dayton 2, Ohio

There are forwarded herewith five corrected copies of Page 14 of the Final Summary Report on the Development, Manufacture and Metallurgical Study of a Cold Extrusion Process for the Manufacture of 30mm Projectile Bodies, prepared by the Heintz Manufacturing Company on work performed by them under Contract DA-36-038-ORD-14091. These corrected copies should be inserted in the proper place in each summary report and the original Pages 14 destroyed.

FOR THE COMMANDING GENERAL:

A. S. Hitner

1 Incl (5 cys)
Pg. 14 of Summary Rpt

ALFRED S. HITNER
Assistant

SUMMARY REPORT

on

DEVELOPMENT, MANUFACTURE and METALLURGICAL STUDY

of the

PROJECTILE, PRACTICE, 30MM, T304

PROJECTILE, PRACTICE, 30MM, T241

PROJECTILE, TARGET PRACTICE, 30MM, T328

SHELL, H.E.I., 30MM., T306E10

HEINTZ MANUFACTURING COMPANY

Steelprest

PHILADELPHIA 20, PA.

HEINTZ MANUFACTURING COMPANY

FRONT STREET & OLNEY AVE. Steelpress PHILADELPHIA 20 · PENNA.

October, 1955

Commanding General
Frankford Arsenal
Bridge & Tacony Streets
Philadelphia 37 Pennsylvania

FC

Re Report on 30mm Shell
Contract DA-36-038-ORD-14091

Dear Sir

We are pleased to hand you herewith the detailed record of the development, manufacture and examination of 30mm projectiles of four types--all made by cold forming operations including cold extrusion.

That cold forming is the recommended way to make good and cheap shell of such size is conclusively shown not only in this report but in our earlier experience in making other 30mm projectiles for Picatinny Arsenal and an European customer.

Strength requirement--90,000 psi minimum yield--was met with a liberal margin and with a useful amount of ductility.

Firing results were "uneventful", according to informal word.

Tonnages noted in making these shell, ranged from a top of 105 on T304, 118 on T328, 159 on T241 and 233 on T306E10 and down to 10 tons. These developmental loads would be reduced by operational and minor design changes. Tool life accordingly would be expected to be satisfactorily very high. Presses desirable in a production line are described in the Appendix.

Facilities to produce up to 3,000 shell per hour in a single line--evolved in studies by us in considerable detail--would be highly efficient, even though flexible to the extent of making projectiles and other bodies, both larger and smaller than the 30mm types, in both weight and size.

Frankford Arsenal October, 1955

As to economics of the method, costs would be lower than any other current method, given recommended equipment and service requirement quantities, due in part to saving in metal.

Strategic saving of material--apparently not yet a major factor in choosing a method--will dictate cold forming beyond any question in any war economy.

Confirmed by a considerable exchange of actual visits it can be noted that European specialists in minor calibre cannon and ammunition have had excellent results from cold formed projectiles in late type weapons, that facilities in certain quarters there are quite limited in various respects as well as size; and that they not yet have access to the advanced technique described and suggested herein--although the interest is high.

The working organization here behind this and similar projects is being kept intact.

It is a pleasure to serve the Ordnance Corps.

Yours faithfully

HEINTZ MANUFACTURING COMPANY

Weber deVore

Manager Ordnance Division

Weber deVore:eb

SUMMARY REPORT

OF

DEVELOPMENT, MANUFACTURE, AND METALLURGICAL STUDY

OF THE

PROJECTILE, PRACTICE, 30MM., T304

PROJECTILE, PRACTICE, 30MM., T241

PROJECTILE, TARGET PRACTICE, 30MM., T328

SHELL, H.E.I., 30MM., T306E10

ON

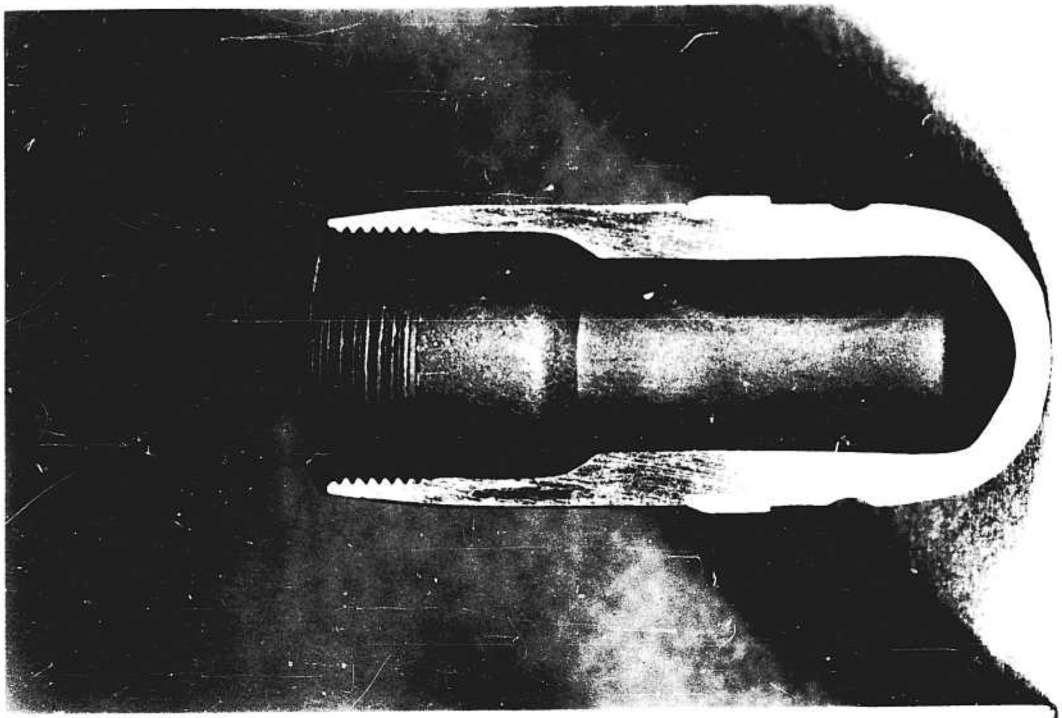
Contract DA-36-038-ORD-14091

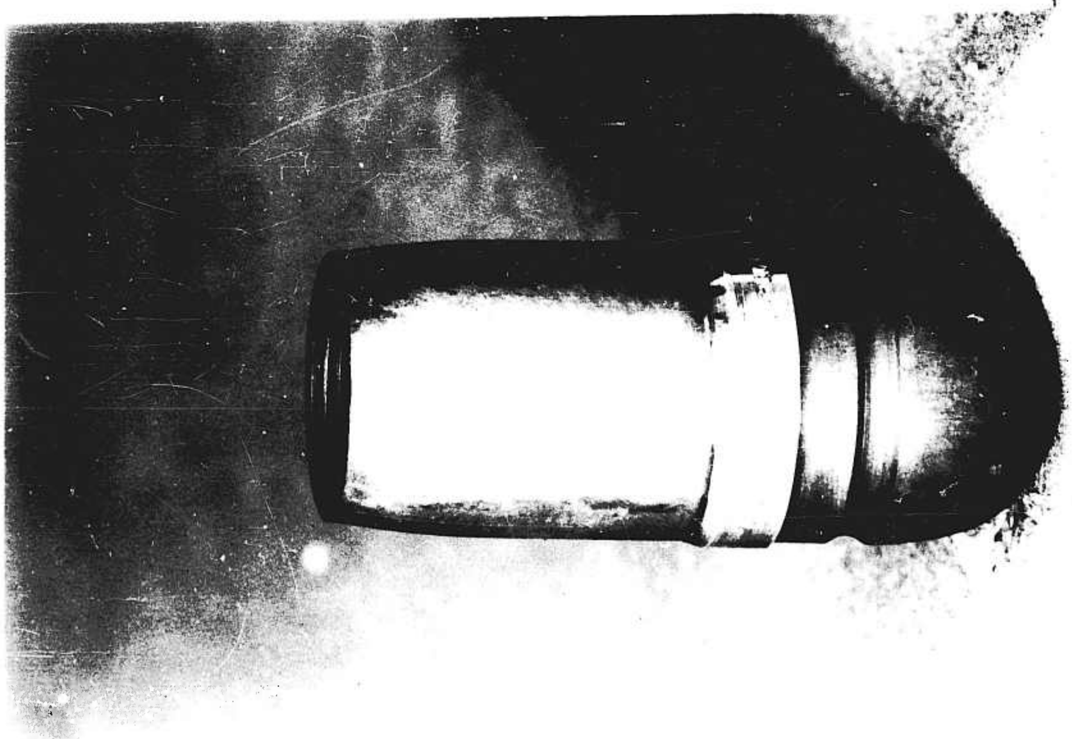
BY

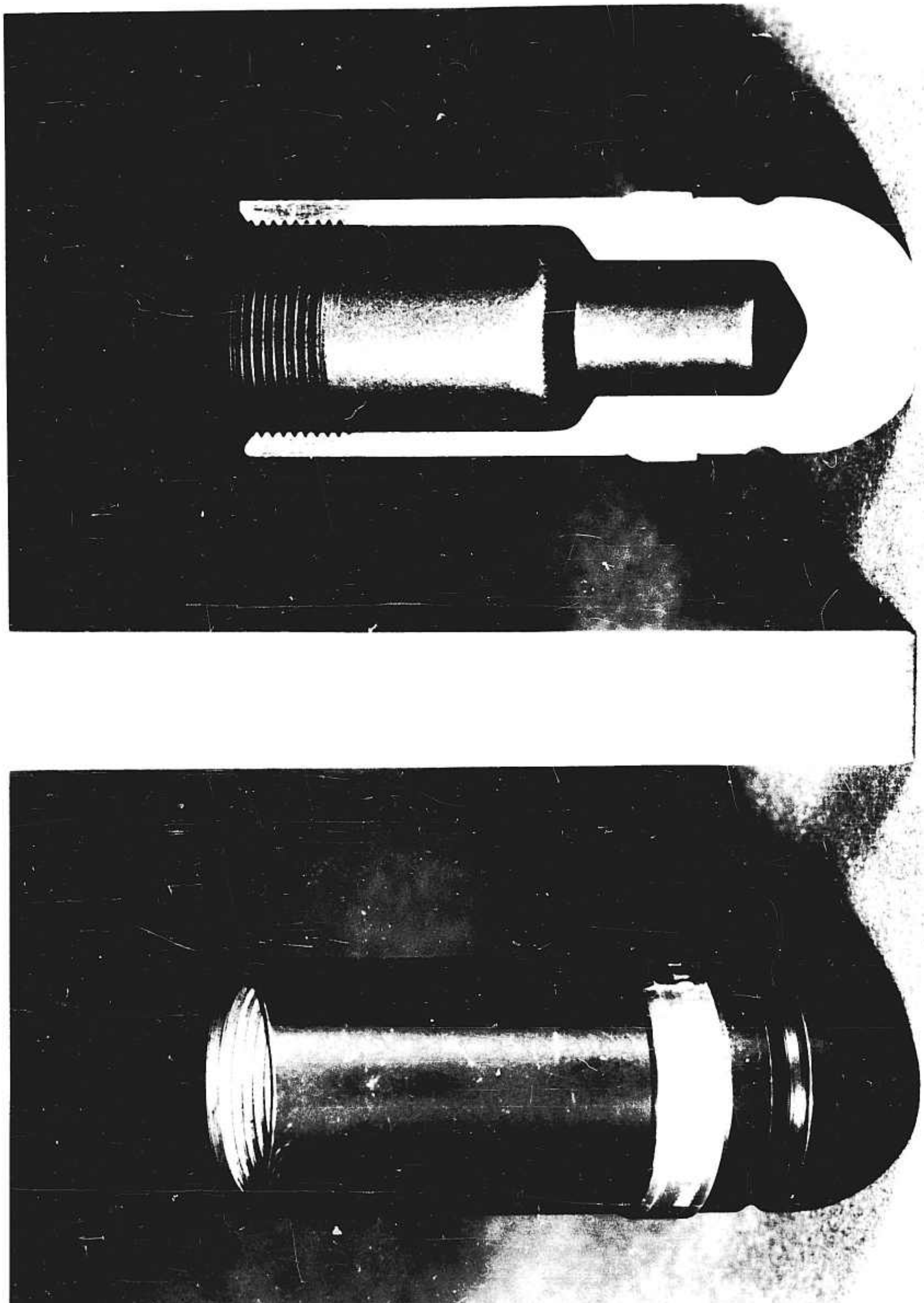
HEINTZ MANUFACTURING COMPANY
PHILADELPHIA, PENNSYLVANIA

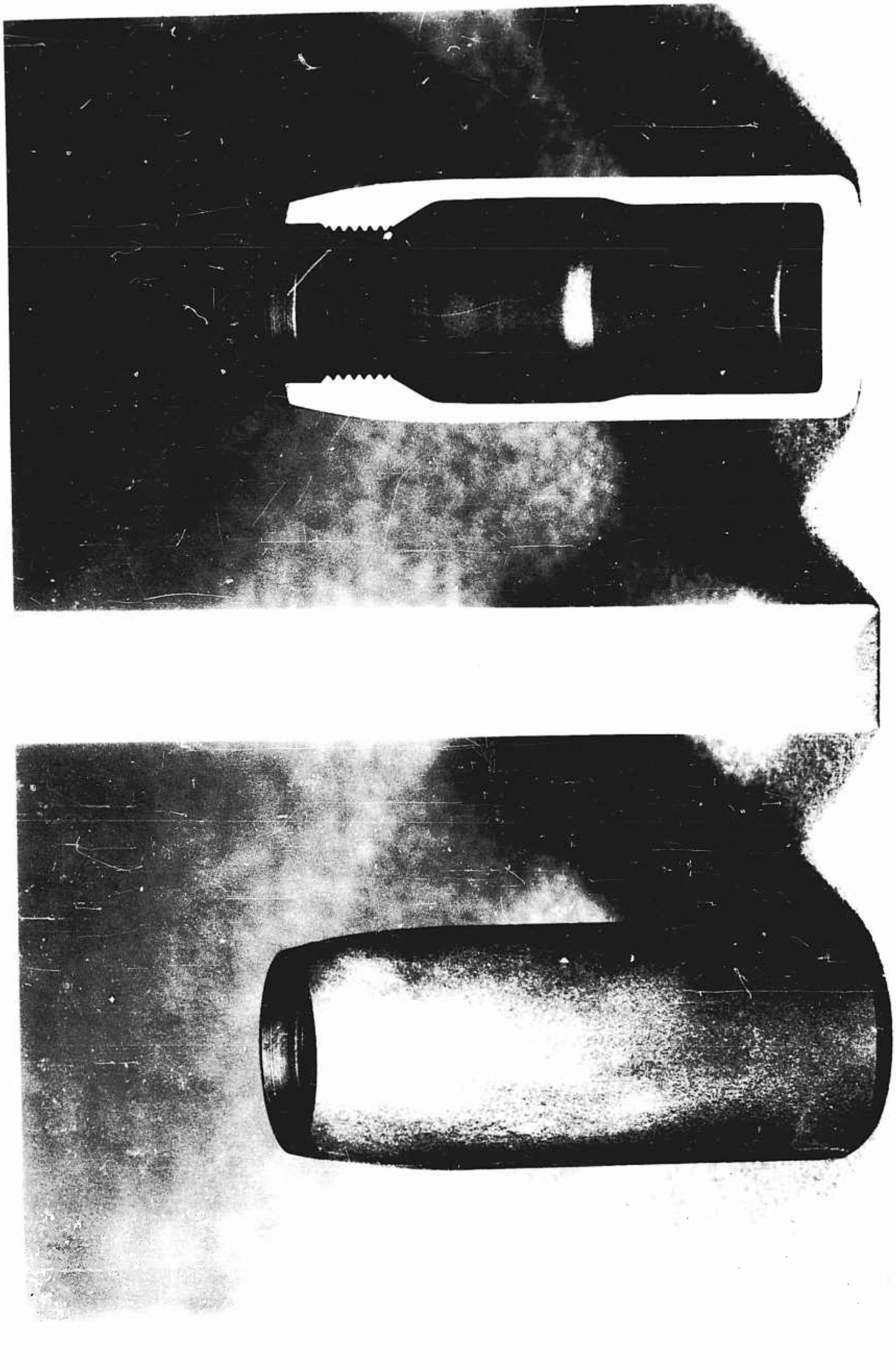
SEPTEMBER, 1955

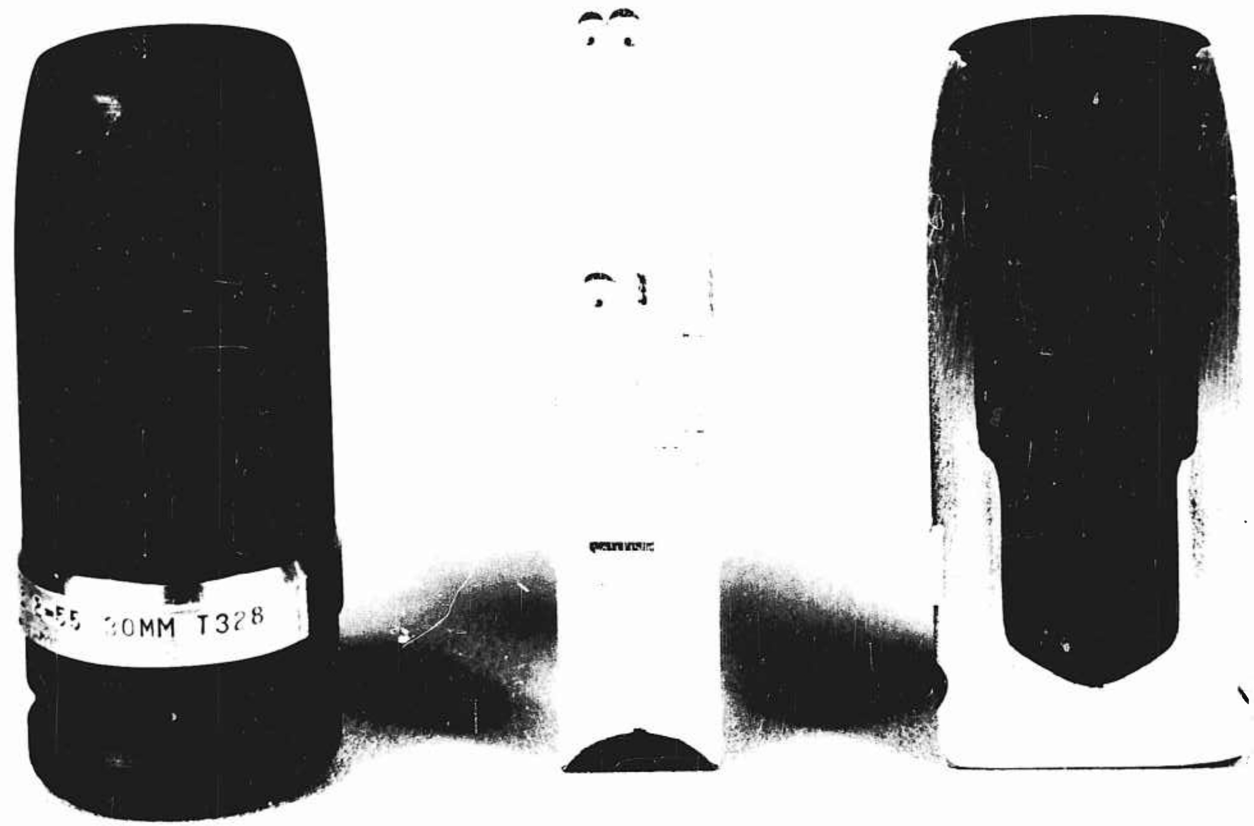
PHOTOGRAPHS










30MM T328

CONTENTS

DRAWINGS

DRAWINGS

DRAWINGS

DRAWINGS

DRAWINGS

PREFACE

We are pleased to submit this summary report on the development, manufacture, and metallurgical study of the 30mm shell bodies as required by Contract DA-36-038-ORD-14091, as amended.

-----o-----

The original contract required in part that we "........ produce a complete set of tooling necessary to produce bodies, projectile, steel, 30mm, manufactured by extrusion from bar stock, stress relieved. Bodies shall conform to the following two types:

"a. Bodies conforming to ORD Dwg 7553344, Rev 2, dated 16 January 1953, except as modified with respect to the inside radii by Heintz Manufacturing Company Sketch Rev 16 February 1953.

"b. Bodies conforming to Sketch FSA 7757, Rev 7, dated 12 March, 1953, except as modified with respect to inside radii by Heintz Manufacturing Company Sketch Rev 16 February 1953."

And further, ".......the tooling to be delivered by the contractor shall be suitable for production of at least 50, 000 each of these two bodies.

"A total of 5, 000 of each of these two bodies produced

on the tooling designed for these bodies shall be delivered by the contractor f.o.b. Frankford Arsenal. A pilot lot of 25 to 100 each of these two bodies shall be delivered by the contractor f.o.b. Frankford Arsenal for approval prior to the production of the said 5,000 each of these two bodies."

-----o-----

Change Order No 1 (12 November 1953) provides "..... pursuant to General Provisions, 2, Changes, of the contract, you are hereby authorized to incorporate in the base of the projectile the addition of a small flat indicated on sketch number 10290 dated 22 October 1953, of 9/16" diameter, which will join the rest of the spherical surface with no sharp edge or other deformation."

Change Order No 3 (16 March 1954) provides "..... you are hereby authorized to change the dimensions on the 30mm projectile T241, D-7553344 to 3.006 plus .000 minus .020 with no change in weight requirement, in lieu of 3.138 plus .000 minus .020."

Change Order No 4 (12 April 1954) states "..... you are hereby directed to change the two (2) types of Bodies for which tooling is to be delivered, to conform to the following types:

"Type 1: Body, Projectile, Practice, 30mm, T328,
conforming to Dwg FD 18088, dated 26

PREFACE (Cont.)

February 1954.

"Type 2: Body, Shell, HEI, 30mm, T306E10, conforming to Dwg FD 18083, Rev 1 dated 17 February 1954.

"A pilot lot of fifty (50) to one hundred (100) each of these two (2) Bodies shall be delivered to Frankford Arsenal for approval; and production of 5,000 each of the two (2) Bodies shall be furnished after approval of the respective pilot lot."

Supplemental Agreement No 5 (1 December 1954) provides in part".....the quantity of 5,000 each Bodies, Projectile, 30mm, T328 (Dwg FD 18088) shall be finish machined, banded, painted, and packaged in accordance with standard commercial practices to insure safe delivery to destination.

"The quantity of 5,000 each shell, projectile, 30mm, HEI, T306E10, (Dwg FD 18083) shall <u>not</u> be banded and shall be completely machined except for machining rotating band and the crimp groove. Shell bodies are <u>not</u> to be painted but are to be packaged in accordance with standard commercial practice to insure safe delivery to destination."

Supplemental Agreement No 6 (18 February 1955) provides for an extension of the delivery schedule.

SUMMARY

This contract, as amended, required that four different 30mm shell bodies be produced by the methods of cold extrusion. They were the T241, T304, T328 and HEI T306E10.

The scope of this contract did not demand that the refinement of detail necessary for mass production be perfected. All of the work, therefore, comprising the cold forming phase of this project was performed using existing presses, surface treating equipment and annealing furnaces. This equipment was far too massive for these small shell. The presses employed were rated at tonnages greatly in excess of that required and the strokes they made per minute were correspondingly few. The surface treating equipment was equally ill-suited. It was necessary to fabricate temporary containers in an effort to utilize the present equipment with some detrimental effect on the quality of the phosphate coating. The shell were annealed in large electrically energized batch type furnaces.

The use of this heavy equipment in no way detracted from the development of the essential mechanical, chemical and metallurgical principles which are applicable to production. Listed in the Appendix are suggestions concerning the equipment necessary for economical mass production of these shell.

The first portion of the cold forming phase of this project was to determine the sequence of press operations, anneals and surface treatment that would produce not only a dimensionally correct shell but also a shell which had been plastically formed to just the proper degree to impart the required mechanical properties. The variety of shapes found among these four shell required three distinct approaches. Therefore, the description of the manufacturing operations will be divided into three parts. The first will include the bodies T241 and T304, which were similar in nature in that both were made with the following basic sequence of press operations:

1. Shear
2. Size
3. First Backward Extrude
4. Second Backward Extrude
5. Nose

The T328 body was produced using a similar basic sequence but the flat bottom and deep backward extrusion imposed a different set of problems.

The HEI T306E10 shell body was manufactured using an entirely different type of operations which were fundamentally:

1. Shear
2. Size
3. Backward Extrude
4. Forward Extrude
5. Draw & Coin
6. Nose

SUMMARY (Cont.)

The press operations produced all of these shell with the internal and external contour finished with the exception of the threads and the band groove and crimping groove.

All of the machining equipment available at Heintz Manufacturing Company was suitable only for much larger work. It was necessary, therefore, to subcontract.

The machining of bodies T241 and T304 was subcontracted to G M Co. Mfg., Inc., of Long Island City, New York, while the bodies T328 and HEI T306E10 were sent to Pantex, Inc., of Pawtucket, Rhode Island. Both of these companies had machined 30mm shell from bar stock using automatic screw machines, and had the necessary form tools, rotating bands, inspection gages, jigs and fixtures, etc., for these shell.

The machining of the nose end of the shell body consisted of facing to length and boring and tapping the thread. With the shell reversed, the band seat was formed and knurled, the band applied and formed and the crimping groove machined.

The shell were then finished and packed as required.

Government inspection and testing were done at Frankford Arsenal.

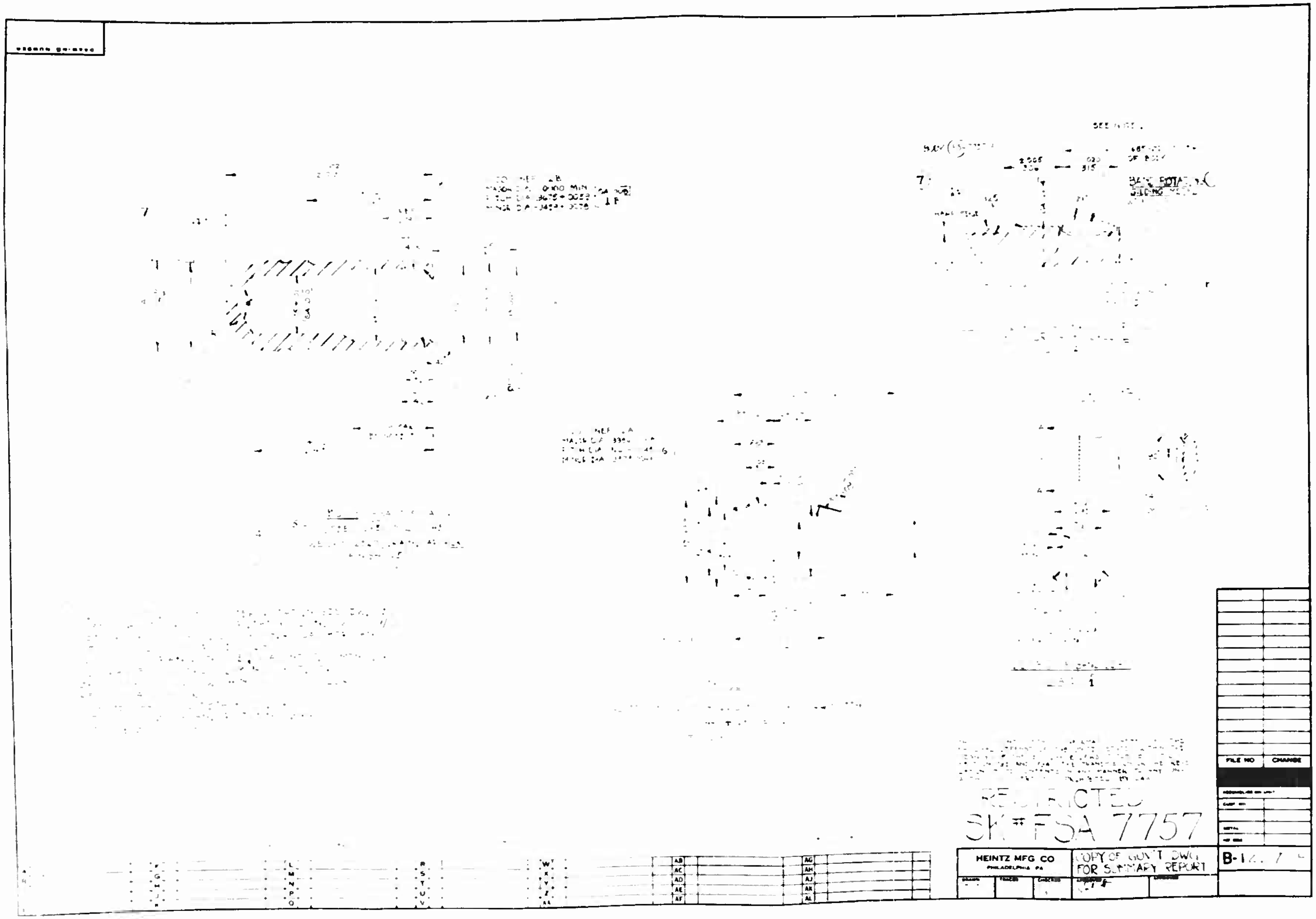
CONCLUSIONS

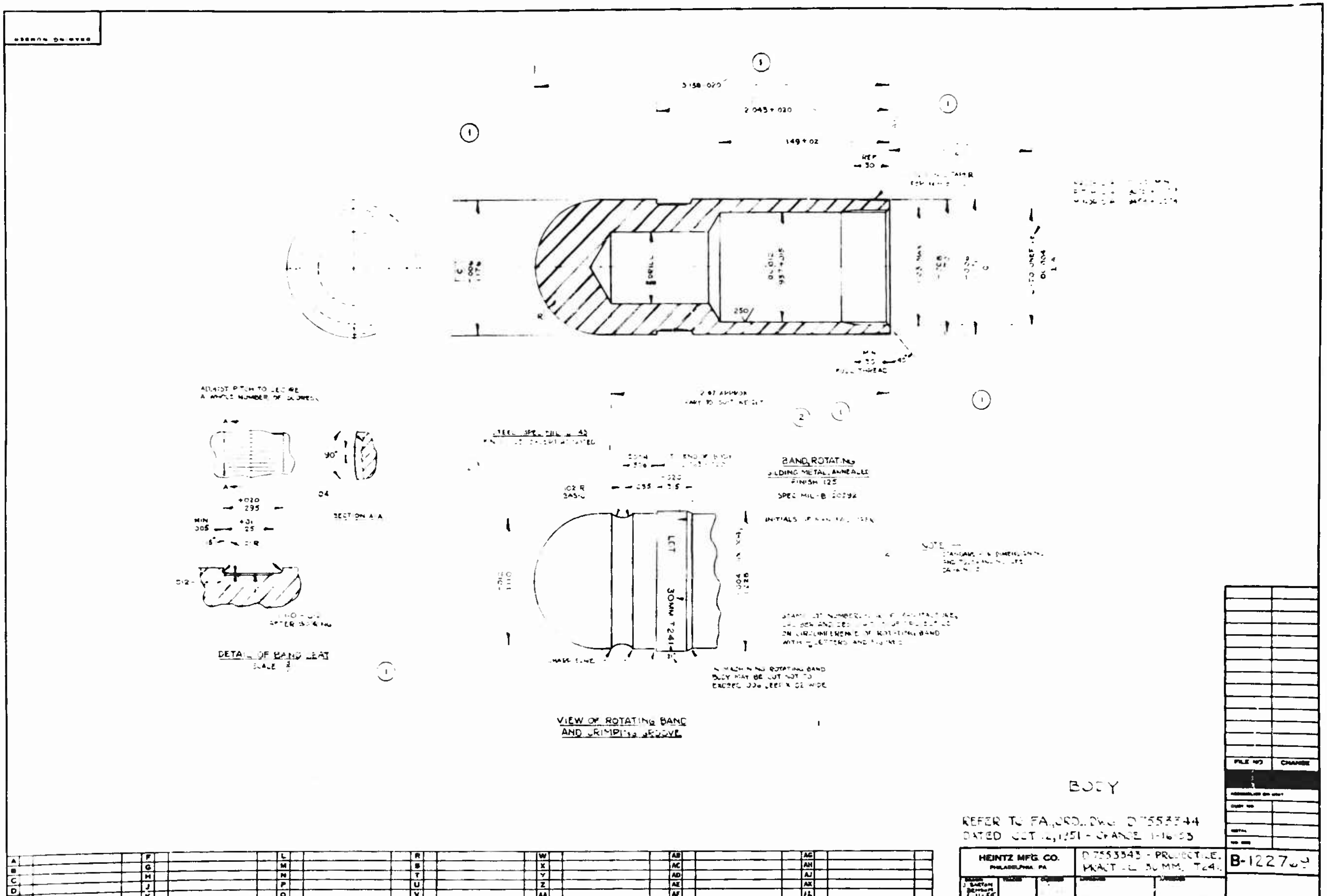
This development project clearly demonstrates the practicality and advisability of using the methods of cold extrusion to fabricate small caliber ammunition of this type.

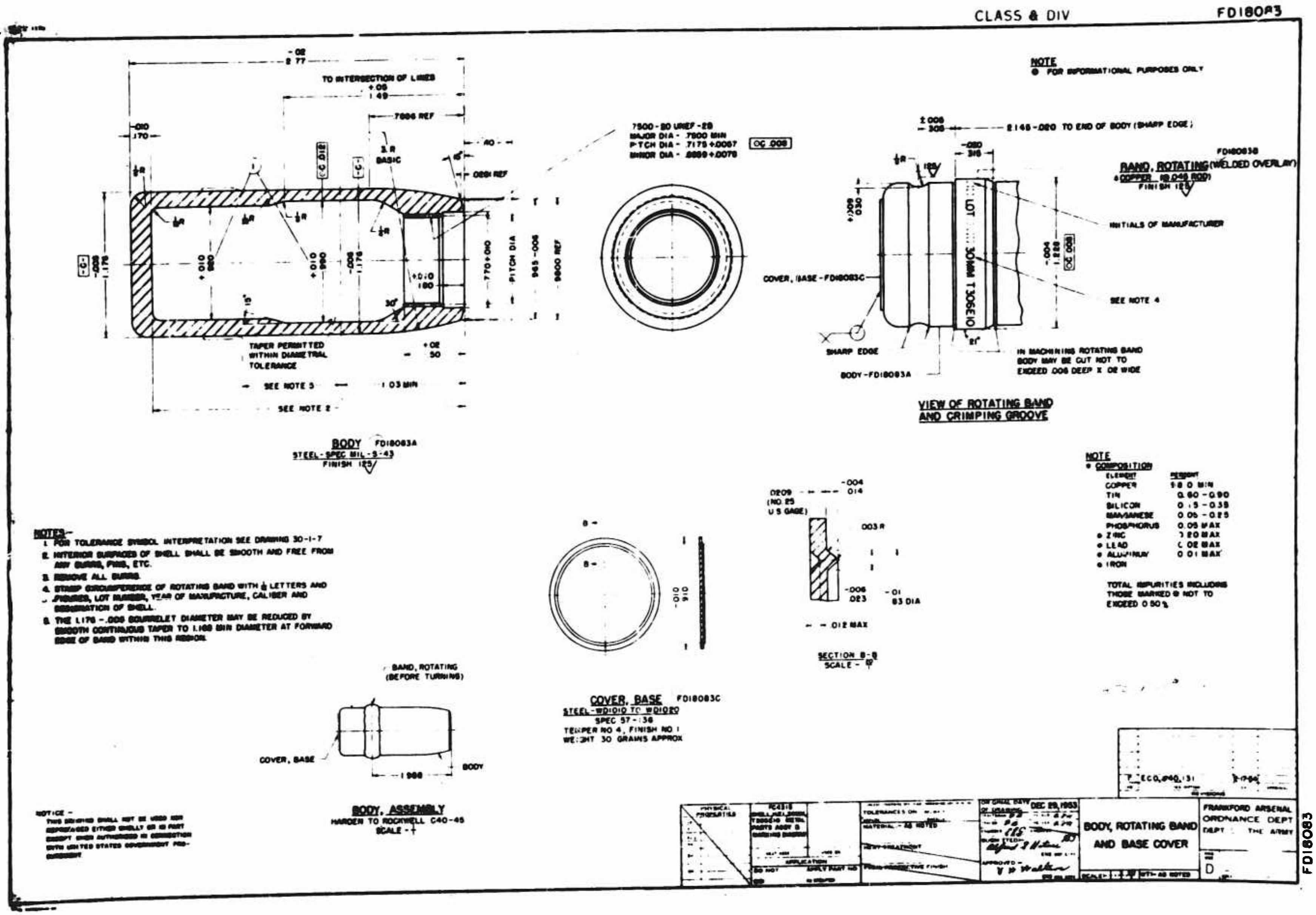
(Although the scope of this contract did not include the economic aspects of the method of manufacture, a casual study of this and other methods indicates clearly that both strategically and economically high production of such items by the methods used would have considerable advantage. Easily obtainable high speed equipment can produce these shell at a saving in material (both quantity and quality) and in cost.)

Cold extrusion, with its relative ease of precision duplication, converts hot rolled bar stock into a finished piece with superior finish and requiring only the minimum of machining. The required mechanical properties are imparted to the shell as an inherent part of the process eliminating entirely the necessity of quench hardening and tempering.

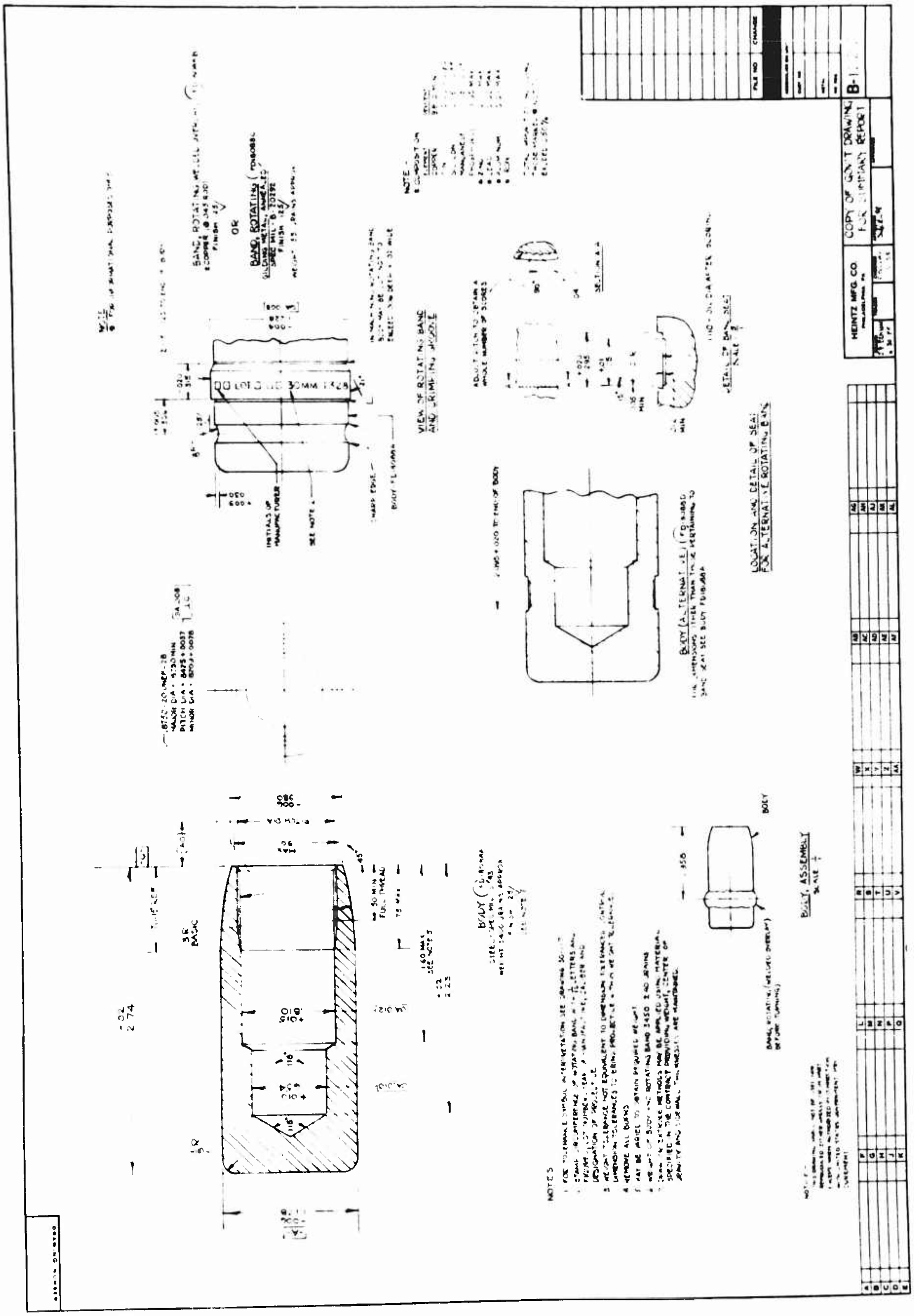
The tooling is readily adaptable to high speed presses and automatic feeding devices.


RESTRICTED
SK # FSA 7757
HEINTZ MFG CO
PHILADELPHIA PA
COPY OF GOV'T DWG
FOR SUMMARY REPORT
FILE NO
CHANGE


3.158 .020
2.045 + .020
149 + .02
REF .30
2.87 APPROX
ADJUST PITCH TO SECURE A WHOLE NUMBER OF SLOPES
90°
SECT ON A-A
DETAIL OF BAND SEAT
BAND ROTATING
GILDING METAL ANNEALED
FINISH 125
SPEC MIL-B
LOT
30MM T241
VIEW OF ROTATING BAND AND CRIMPING GROOVE
BODY
REFER TO FA ORD. DWG D7553344
HEINTZ MFG. CO.
PHILADELPHIA PA
B-12276



CLASS & DIV
FD18083
NOTE
FOR INFORMATIONAL PURPOSES ONLY
TO INTERSECTION OF LINES
BODY FD18083A
STEEL - SPEC MIL-S-43
TAPER PERMITTED WITHIN DIAMETRAL TOLERANCE
SEE NOTE 5
SEE NOTE 2
7500-20 UNEF-2B
MAJOR DIA - .7500 MIN
PITCH DIA - .7175+.0067
MINOR DIA - .6889+.0078
COVER, BASE - FD18083C
SHARP EDGE
BODY - FD18083A
INITIALS OF MANUFACTURER
SEE NOTE 4
IN MACHINING ROTATING BAND BODY MAY BE CUT NOT TO EXCEED .006 DEEP X .02 WIDE
VIEW OF ROTATING BAND AND CRIMPING GROOVE
BAND, ROTATING (WELDED OVERLAY)
LOT 30MM T306E10
NOTES -
1. FOR TOLERANCE SYMBOL INTERPRETATION SEE DRAWING 30-1-7
2. INTERIOR SURFACES OF SHELL SHALL BE SMOOTH AND FREE FROM ANY BURRS, FINS, ETC.
3. REMOVE ALL BURRS.
4. STAMP CIRCUMFERENCE OF ROTATING BAND WITH LETTERS AND FIGURES, LOT NUMBER, YEAR OF MANUFACTURE, CALIBER AND DESIGNATION OF SHELL.
5. THE 1.176 -.006 BOURRELET DIAMETER MAY BE REDUCED BY SMOOTH CONTINUOUS TAPER TO 1.168 MIN DIAMETER AT FORWARD EDGE OF BAND WITHIN THIS REGION
SECTION B-B
COVER, BASE FD18083C
SPEC 57-136
TEMPER NO 4, FINISH NO 1
WEIGHT 30 GRAINS APPROX
NOTE
COMPOSITION
ELEMENT
PERCENT
COPPER
TIN
SILICON
MANGANESE
PHOSPHORUS
ZINC
LEAD
ALUMINUM
IRON
TOTAL IMPURITIES INCLUDING THOSE MARKED NOT TO EXCEED 0.50%
BAND, ROTATING (BEFORE TURNING)
COVER, BASE
BODY
BODY, ASSEMBLY
HARDEN TO ROCKWELL C40-45
FRANKFORD ARSENAL
ORDNANCE DEPT
DEPT THE ARMY
BODY, ROTATING BAND AND BASE COVER
DEC 29, 1953
D



BODY, ASSEMBLY
VIEW OF ROTATING BAND AND CRIMPING GROOVE
SECTION A-A
NOTES
HEINTZ MFG. CO.
COPY OF GOV'T DRAWING FOR COMPANY REPORT

TECHNICAL INFORMATION

The sequence of manufacturing operations listed and described hereafter was used to make pilot lots and production runs up to 5,000 pieces. While this represents a small total number of shell produced, the principles, the methods, and the tools are analogous to those used to make similar, if larger, components on a mass production basis.

The several basically different approaches that were necessary to make these four shell require that each approach be described separately. Therefore the work described hereafter will be presented as follows:

1. Shell Designation
   - a. Engineering Considerations
   - b. Cold Forming Operations and Applicable Tool Drawings
   - c. Machining Operations and Applicable Drawings
   - d. Metallurgical Data and Discussion

BODY, PROJECTILE, PRACTICE, 30MM

T304 and T241

BODY, PROJECTILE, PRACTICE, 30MM

T304 and T241

ENGINEERING CONSIDERATIONS

These two shell were so similar with respect to physical shape and mechanical properties that this discussion of the engineering problems is applicable to both.

The general requirement was to manufacture a shell dimensionally consistent with the required drawings and having a minimum yield strength of 90,000 psi with an elongation of 10% in a gage length of four (4) diameters. The mechanical properties were to be derived from work hardening the material.

To assure that these requirements were met a sequence of operations compatible with the requirements of both shape and mechanical properties had to be properly determined. The general method of approach is to engineer the sequence with respect to shape and dimensional requirements only and then select a material which will, at the calculated strain, have approximately the mechanical properties desired. Then the sequence, material, process anneals and final stress relief anneal are modified to give the desired result.

In the particular case of these two shell bodies, which had been designed for production on automatic screw machines, it was first necessary to modify the sharp corners in the cavity with radii. This was essential in that the material flowing from under the punch

did not have sufficient ductility to form around the sharp edges and would rupture. Also such sharp corners had a deleterious effect on the lubricating properties of the phosphate coating.

The cavity and general shape of these bodies lent themselves admirably to forming by successive backward extrusion operations followed by nosing to form the ogive. The difference in internal diameters, with a constant outside diameter, resulted in a 65% reduction in area at the top of the shell and a 27% reduction in area at the bottom in the extreme case of the T241 body. The smaller reduction therefore governed the extent of the work hardening. A reduction in area of 27% should increase the "as rolled" yield point approximately 85% and decrease the elongation by approximately 55%. Therefore, a steel with yield strength of approximately 50, 000 psi and an elongation of 36% in the "as rolled" condition should be selected. A plain carbon steel with about 20 points of carbon meets these conditions.

Since the sequence of operations selected with a series of backward extrusions, where the metal worked by the first backward extrusion was <u>not</u> further strained by the second backward extrusion. This, of course, precluded the use of any anneals following the first extrusion.

Economic considerations made it mandatory that the billets be sheared from the bars rather than sawed. This shearing operation produced a distorted slug of metal with a very irregular and severely cold worked top and bottom face. To prepare this slug for the first backward extrusion operation, it was necessary to tumble to remove burrs and sharp edges, then to anneal to remove the effects of the shearing, and finally to add another press operation to size this deformed slug into a cylindrical section. If the billets were not sized, the skewed surface of the sheared billet would have caused the punch to enter the piece at an angle and would have made it impossible to hold the shell bodies within the required concentricity tolerances.

Previous experience had indicated that conical punch shapes, as required to form these shell, impose some limitations on the extent to which the phosphate coating may be stretched when forming the metal. This type of punch is not as desirable as one with a flat or hemispherical shape. Experimental work confirmed this thinking and the pieces were surface treated preceding each of the backward extrusion operations as well as after the annealing operation.

With these considerations in mind the necessary volumetric

calculations were made and the sequence drawings shown on the pages immediately following this text were prepared.

The complete theoretical or basic sequence of cold forming operations was therefore:

1. Shear billet
2. Tumble
3. Anneal
4. Wheelabrate
5. Surface treat
6. Size
7. Surface treat
8. First backward extrusion
9. Surface treat
10. Second backward extrusion
11. Nose
12. Stress relieve

Once this information was determined, tools were designed and built to make the shapes shown on the sequence drawings, tentative annealing temperatures were selected, required press tonnages were calculated, the auxiliary equipment necessary for surface treatment was fabricated, and the necessary gages, jigs and fixtures were manufactured.

These operations will now be discussed in detail with regard to the practical tooling, metallurgical, chemical and manufacturing problems.

ENGINEERING CONSIDERATIONS (Cont.)

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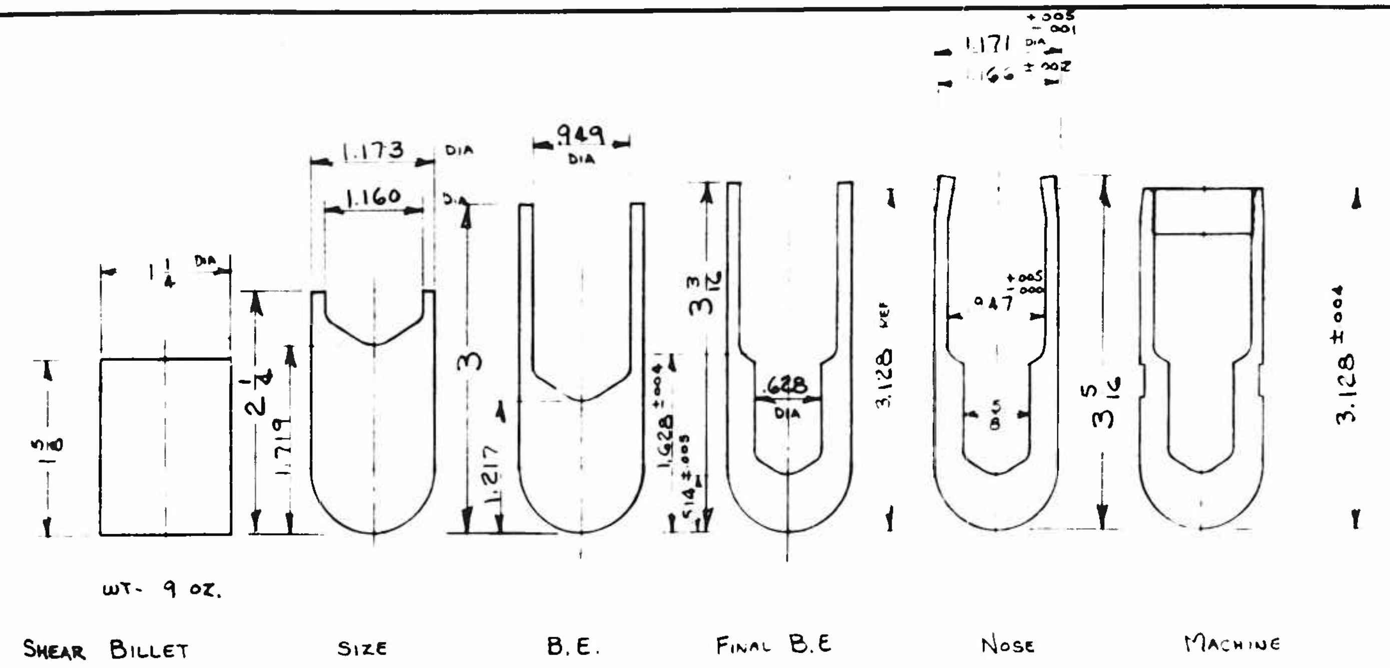


ALL SIZES ARE APPROXIMATE
OR FOR DESIGN & CLEARANCE.

FILE NO.	CHANGE
ASSEMBLIES ON UNIT	
CUST. NO	
METAL	
NO. REQ.	

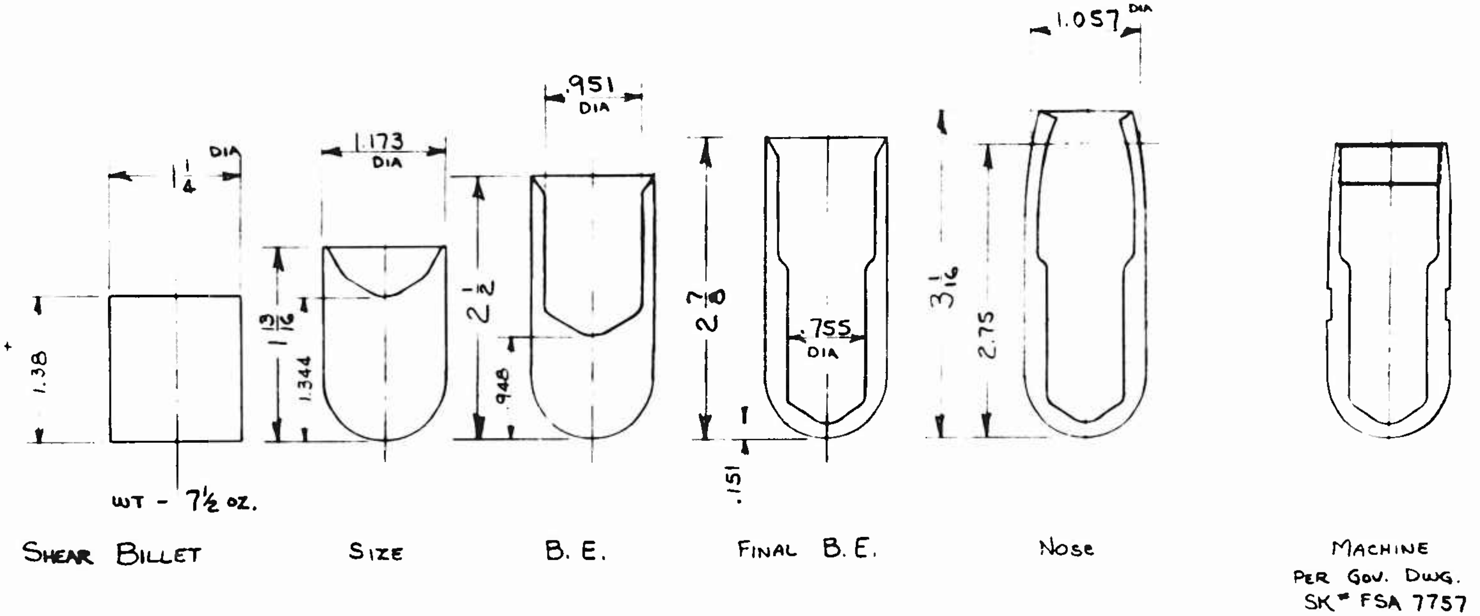
HEINTZ MFG. CO.
PHILADELPHIA, PA.

PROPOSED SEQUENCE OF OPERATIONS
FRANK FORD ARSENAL, PROJECTILE
PRACTICE 30 MM T241, D 7553344

DRAWN	TRACED	CHECKED	APPROVED	APPROVED
RIDGWAY 4-15-53		J. B. BENSON 4-17-53	7 ... 4-?-53	

E-122716

A B C D E F G H J K



ALL SIZES ARE APPROXIMATE
OR FOR DESIGN & CLEARANCE

FILE NO.	CHANGE

ASSEMBLIES ON UNIT	
CUST. NO	
METAL	
NO. REQ.	

HEINTZ MFG. CO. PHILADELPHIA, PA.		PROPOSED SEQUENCE OF OPERATIONS FRANKFORD ARSENAL, PROJECTILE PRACTICE 30MM, T304, SK# FSA 7757		E-122717
DRAWN RIDGWAY 4-10-53	TRACED	CHECKED J.B. BENSON 4-12-53	APPROVED T. Konoplisky 4-17-53	APPROVED

A		F	
B		G	
C		H	
D		J	
E		K	

J. H. WEIL & CO., PHILA.

BODY, PROJECTILE, PRACTICE, 30MM

T304 and T241

COLD FORMING OPERATIONS

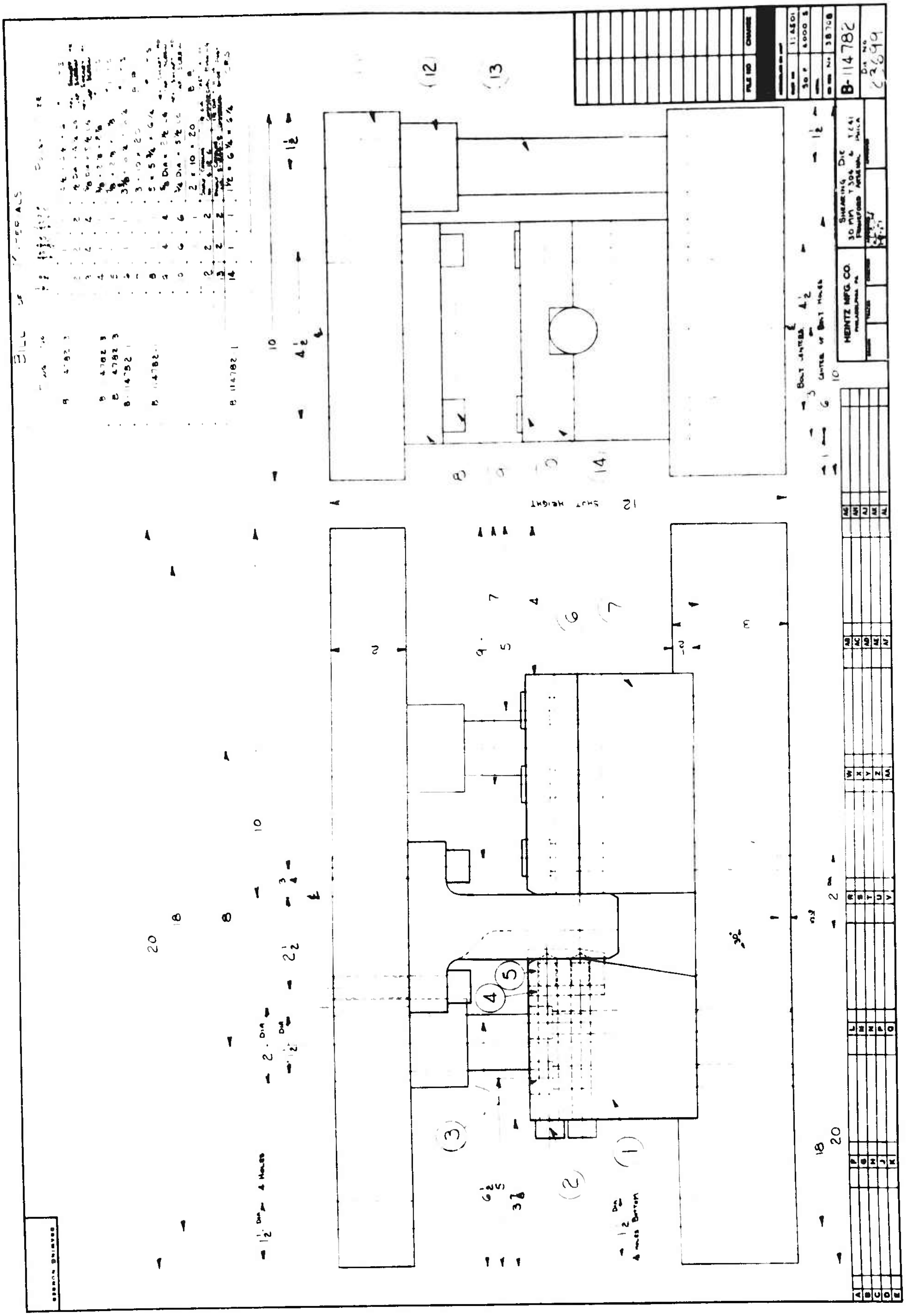
1. SHEAR BILLETS

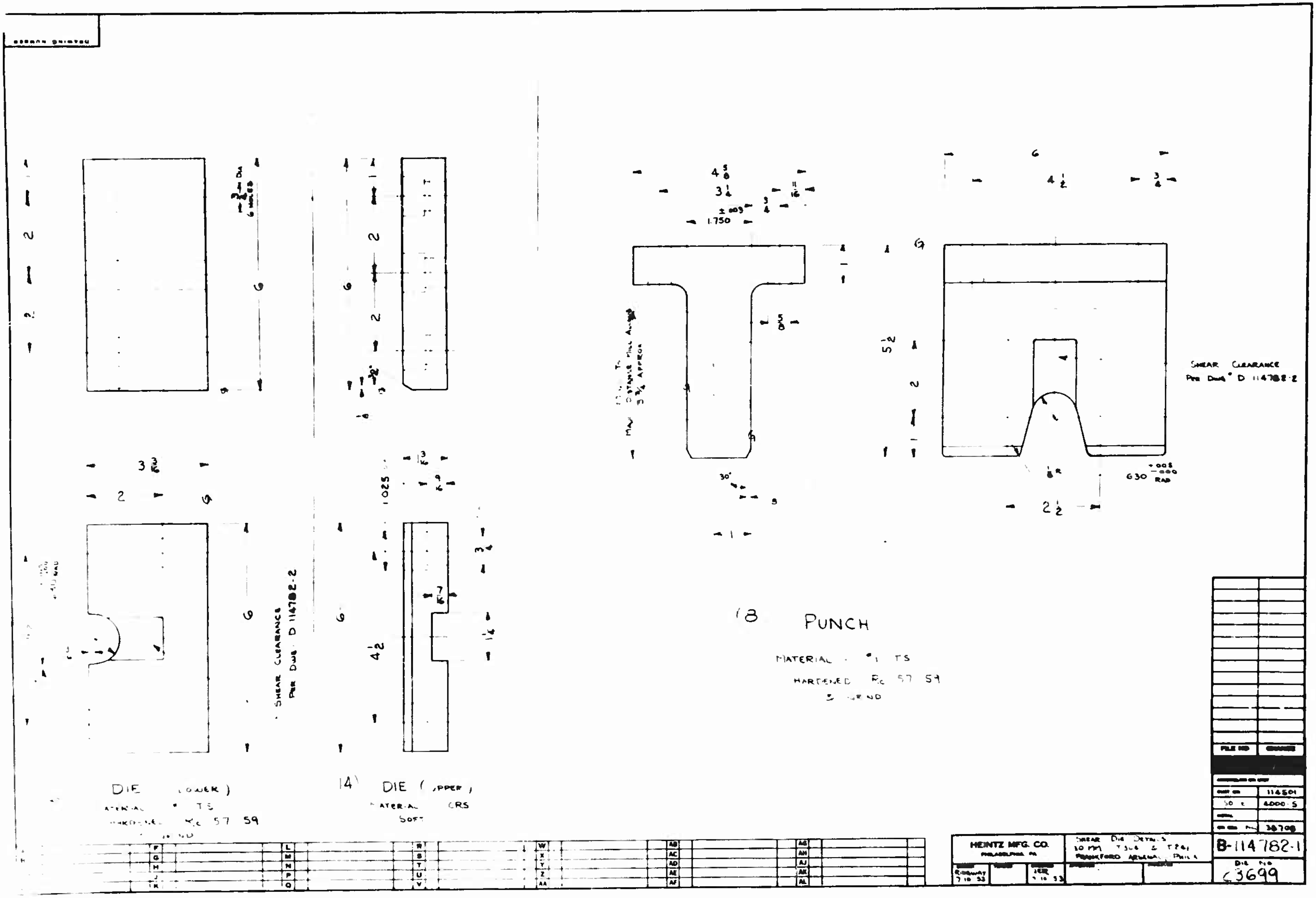
The billets were sheared to the correct weight of nine (9) ounces for the T241 and seven and one-half (7-1/2) ounces for the T304 from one and one-quarter inch (1.250") hot rolled AISI 1021 bar stock. The random length bars were hand fed into the die against the stop block on the upstroke of the press.

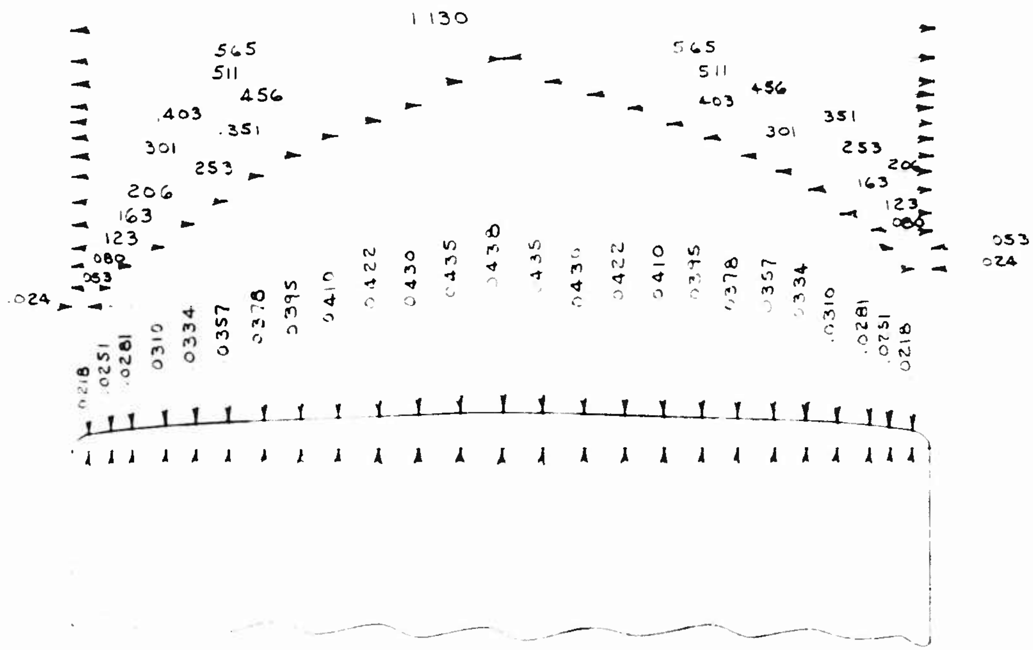
Little difficulty was experienced in performing this operation with the exception of the troublesome accumulation of galled metal from the bar stock which tended to deposit on the stop block. An improved die designed for one particular shell only would allow for a removable block.

The assembly drawing and details of this die appear on the pages immediately following this text.

This die was run on a Verson 100 ton mechanical press. The actual tonnage required was 43 tons.


HEINTZ MFG. CO.
SHEARING DIE
30 MM T304 & T241
FRANKFORD ARSENAL
B-114782
12 SHUT HEIGHT


DIE (LOWER)
DIE (UPPER)
MATERIAL CRS
SOFT
SHEAR CLEARANCE
PER DWG D 114782-2
PUNCH
HARDENED Rc 57 59
HEINTZ MFG. CO.
B-114782-1
63699



Punch & Die Shear Clearance
Template

Scale = 10 x Size

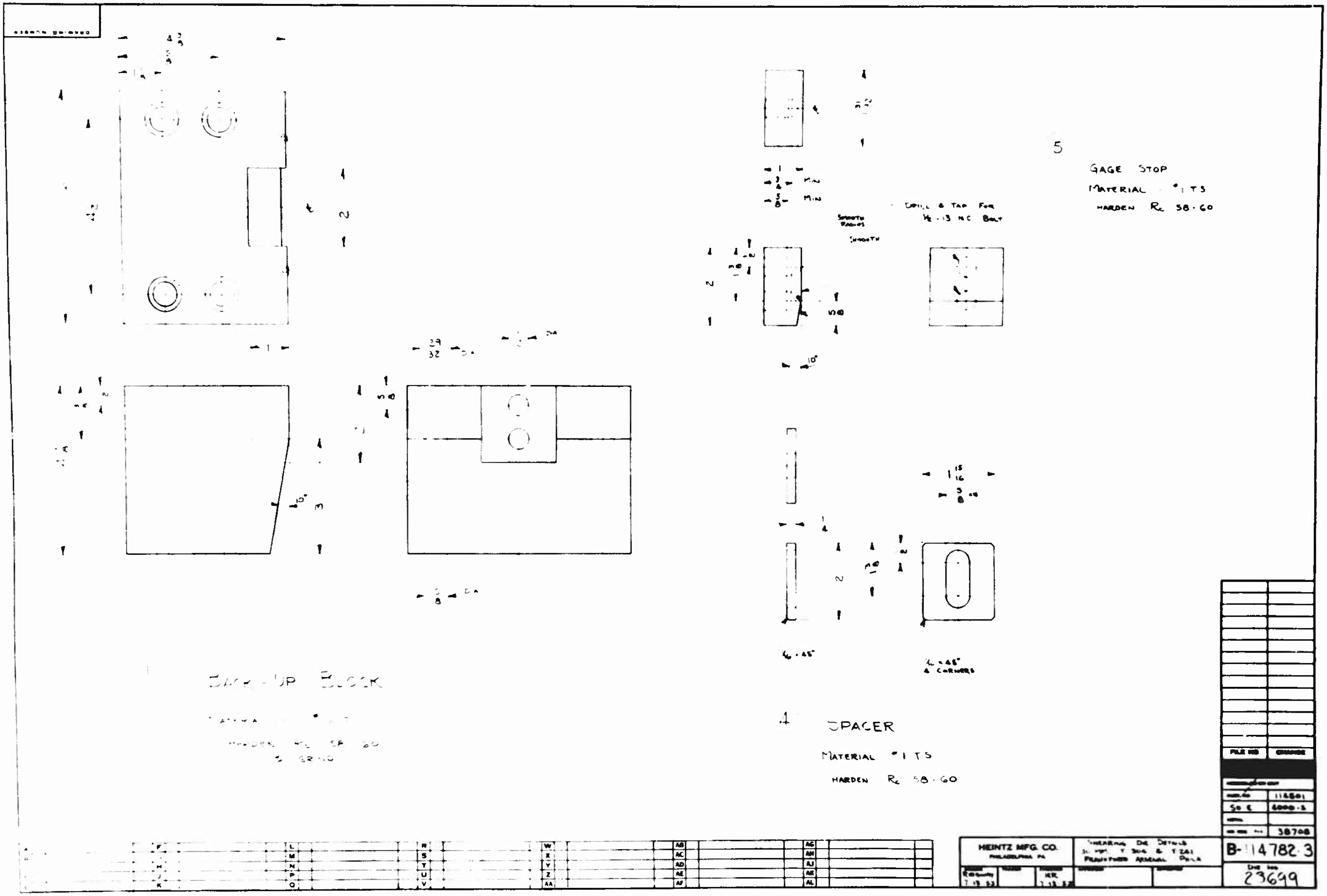
FILE NO.	CHANGE		
ASSEMBLIES ON UNIT			
CUST NO	14501		
METAL			
NO REQ			

HEINTZ MFG. CO.
PHILADELPHIA PA

Shear Clearance Template
30MM Shell
Frankford Arsenal Phila

DRAWN	TRACED	CHECKED	APPROVED	APPROVED
Ridgway 6 22 53				

D-


5
GAGE STOP
MATERIAL #1 TS
HARDEN Rc 58-60
DRILL & TAP FOR
1/4-13 NC BOLT
SMOOTH RADIUS
SMOOTH
MIN
MIN
10°
1/16 x 45°
1/16 x 45°
4 CORNERS
4
SPACER
MATERIAL #1 TS
HARDEN Rc 58-60
BACK-UP BLOCK
29/32
1 15/16
DIA
HEINTZ MFG. CO.
PHILADELPHIA PA.
B-114782-3
23699
116801
38708

BODY, PROJECTILE, PRACTICE, 30MM

T304 and T241

COLD FORMING OPERATIONS (Cont.)

2. TUMBLE BILLETS

The purpose of tumbling was to remove the sharp edges and burrs from the faces of the billet.

This was an economical operation in that it only required a part-time operator to load and unload the tumbler, and in the cycle of forty-five (45) minutes, one thousand (1, 000) pieces could be processed.

3. ANNEAL BILLETS

The sheared surface of the billet was, of course, cold worked to its breaking point. This surface was then incapable of withstanding any further plastic deformation unless it was annealed at a temperature that would restore its original ductility.

The pieces were heated to 1250° F. in an electric furnace, manufactured by the Lindberg Engineering Company, soaked at this temperature for three-quarters of an hour and air cooled. The effect of this anneal is shown, by means of hardness surveys, in the section on metallurgical information.

4. SHOTBLAST BILLETS

All production procedures for cold forming utilize some form of automatic surface treating equipment. With this automatic equipment it is impossible to have a chemical cycle that is compatible with the scaled surface of the billets and the surface of pieces that have been partially formed. Mechanical "Wheelabrating" is the most economical method of removing this tenacious scale.

The pieces were placed on a conveyor which fed them into the machine. They were ejected from the machine automatically by a conveyor which led away from the machine and dropped the pieces into an empty bin.

Soft "nail whiskers" were used for shot. It was very important to have soft shot of some form in that hard shot would imbed itself in the relatively soft piece and then gouge the die when the piece was formed.

5. SURFACE TREAT BILLETS

The surface treatment of billets was performed on the experimental, hand Foscoat line. The pieces were placed in stainless steel (Carpenter #20) trays which we used to modify the existing baskets. The process was as follows:

1. Alkaline clean
2. Cold water rinse
3. Sulphuric acid pickle
4. Cold, overflowing water rinse
5. Hot, overflowing water rinse
6. Foscoat
7. Cold, overflowing water rinse
8. Hot, overflowing water rinse
9. Lubrication

Chemicals were furnished by Pennsylvania Salt Manufacturing Company of Philadelphia.

A complete description of the processes and controls is contained in the Appendix section describing chemical data.

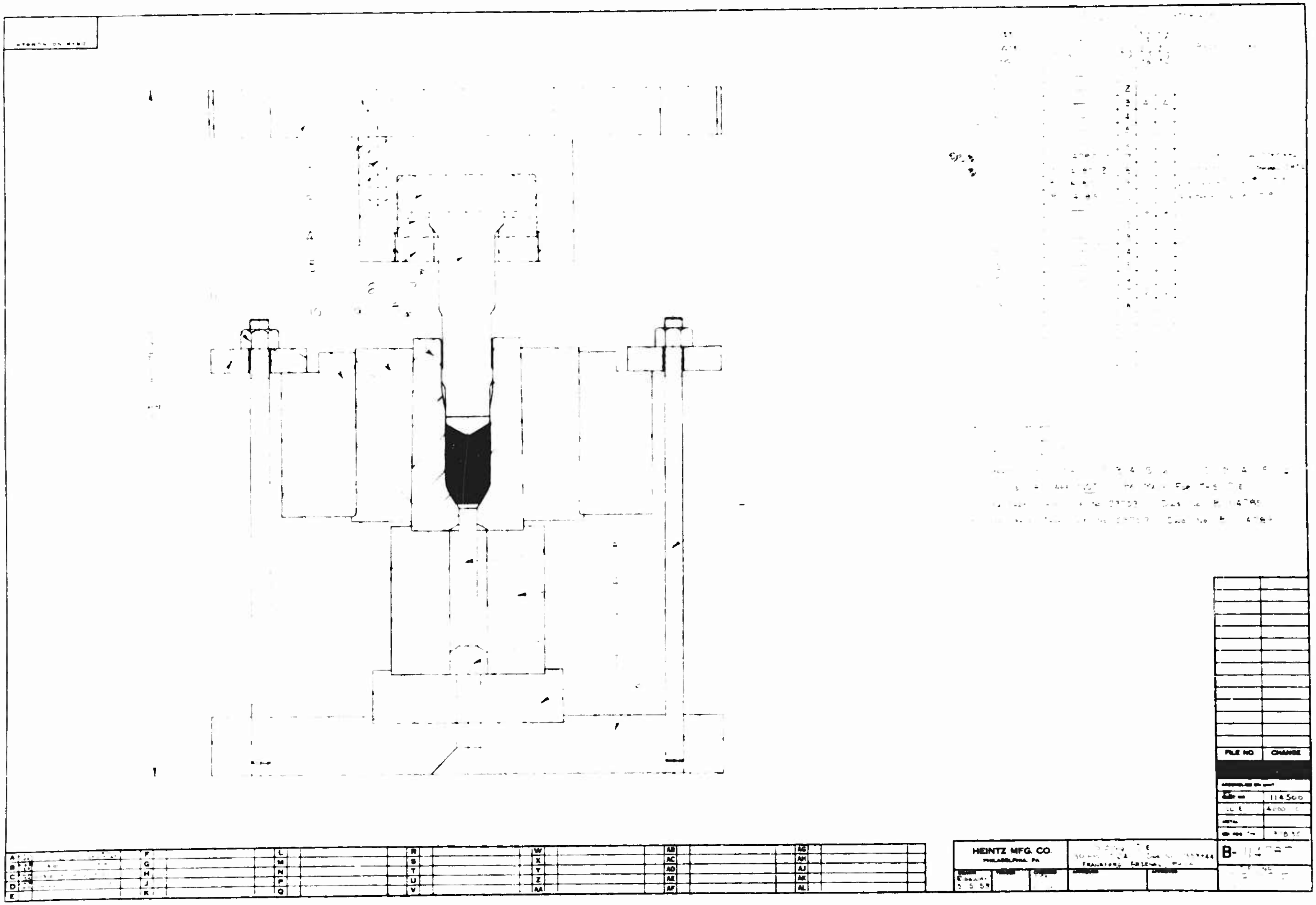
6. SIZE BILLETS

The tools necessary to perform this operation are shown on Dwg #114783 and #114787 on the pages immediately following this text. The punch (item #7), the die (item #8), and the knock-out pin (item #18), were those components which actually formed the piece. The remainder of the die assembly was designed to accommodate not only this operation but all extrusion operations.

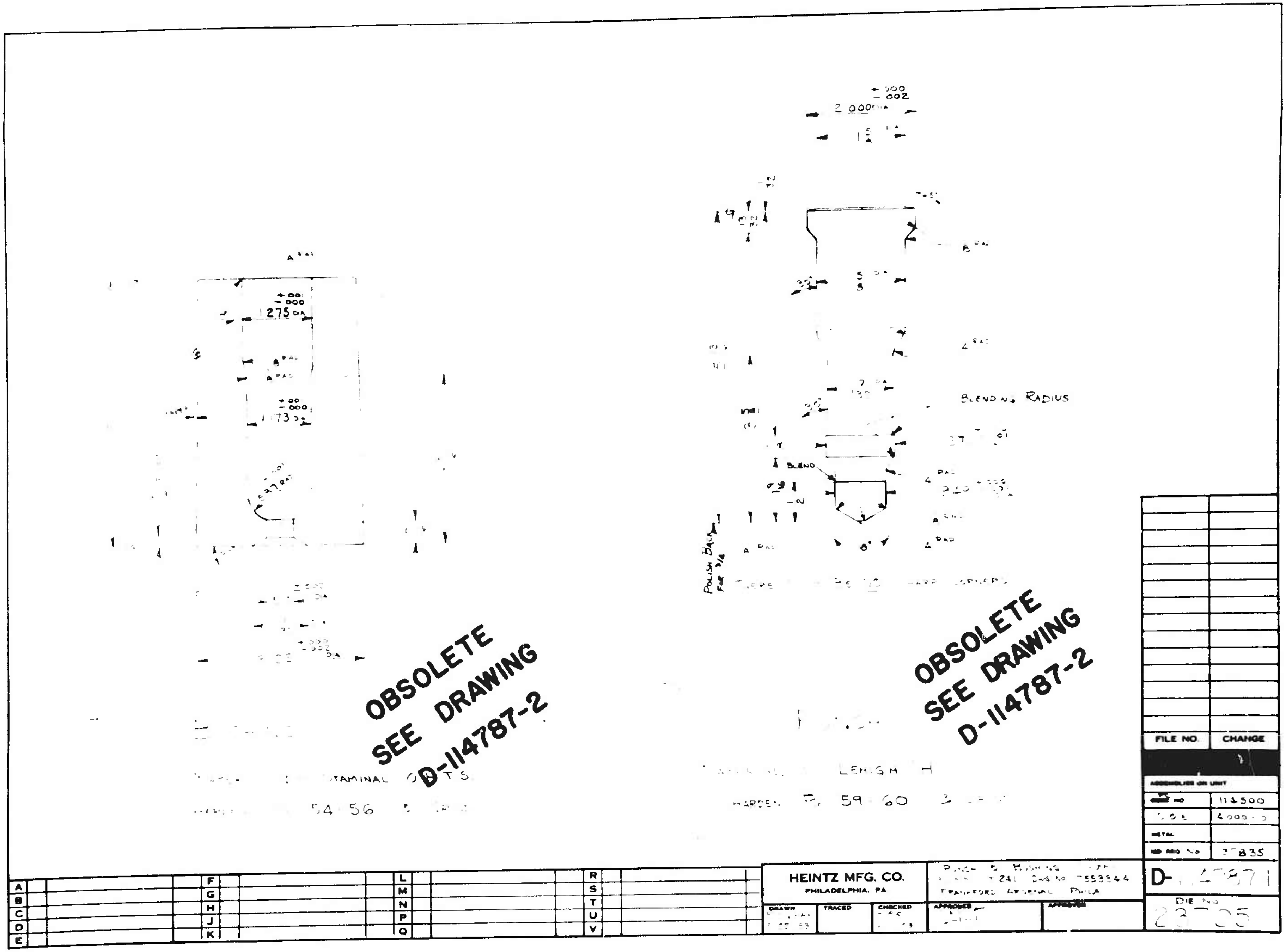
The Foscoated one and one-quarter inch (1-1/4") billet was placed in the die and formed approximately to the shape shown on Dwg #122717 and #122716. Actually, the punch forced the metal to form into the spherical bottom until the vertical forces were balanced; i.e., until a stress level was reached where the metal would flow up around the punch rather than into the die. Considerable difficulty of this nature was experienced and in an effort to form a perfect hemisphere, the punch and die were modified as shown on Dwg #D-114783-1, #D-114783-4, #D-114787-1 and #D-114787-3. These modifications markedly improved the flow problem but were not completely successful in forcing the metal to conform to the

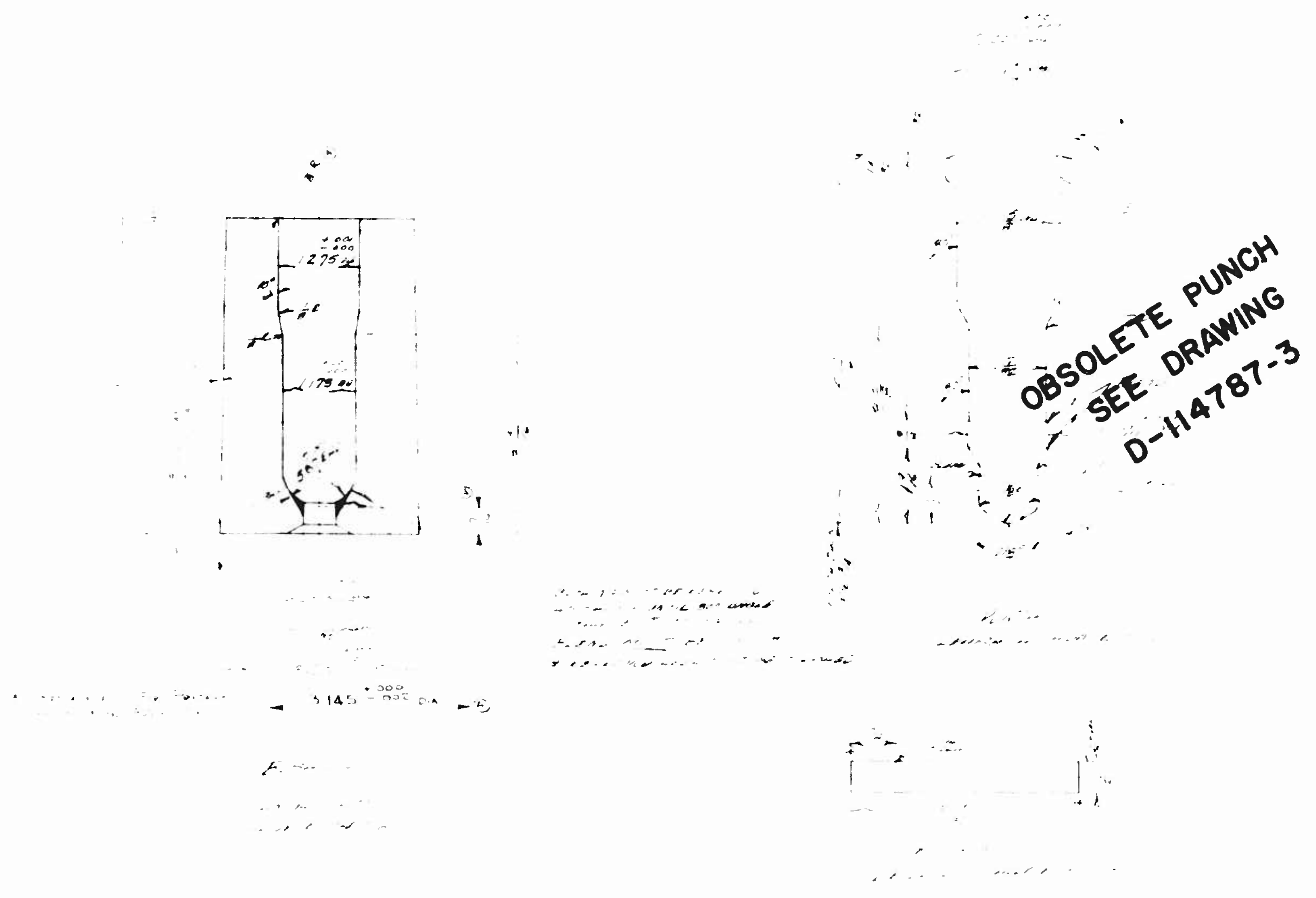
SIZE BILLETS (Cont.)

hemispherical shape. This die was run on a Verson 100 ton single point mechanical press. Actual tonnage required was 159 tons for the T241 and 105 tons for the T304.



HEINTZ MFG. CO.
PHILADELPHIA, PA
FRANKFORD ARSENAL
FILE NO.
CHANGE
114500
B-


OBSOLETE
SEE DRAWING
D-114787-2
OBSOLETE
SEE DRAWING
D-114787-2
2.000 DIA
+.000
-.002
.275 DIA
+.001
-.000
BLENDING RADIUS
BLEND
POLISH BACK FOR 3/4
LENGTH
HARDEN
59-60
54-56
FILE NO.
CHANGE
ASSEMBLIES OR UNIT
114500
37835
HEINTZ MFG. CO.
PHILADELPHIA, PA
DRAWN
TRACED
CHECKED
APPROVED
FRANKFORD ARSENAL PHILA
D-
DIE NO.
A
B
C
D
E
F
G
H
J
K
L
M
N
P
Q
R
S
T
U
V



A		F		L		R	
B		G		M		S	
C		H		N		T	
D		J		P		U	
E		K		Q		V	

HEINTZ MFG. CO.
PHILADELPHIA, PA

DRAWN	TRACED	CHECKED	APPROVED	APPROVED

FILE NO.	CHANGE

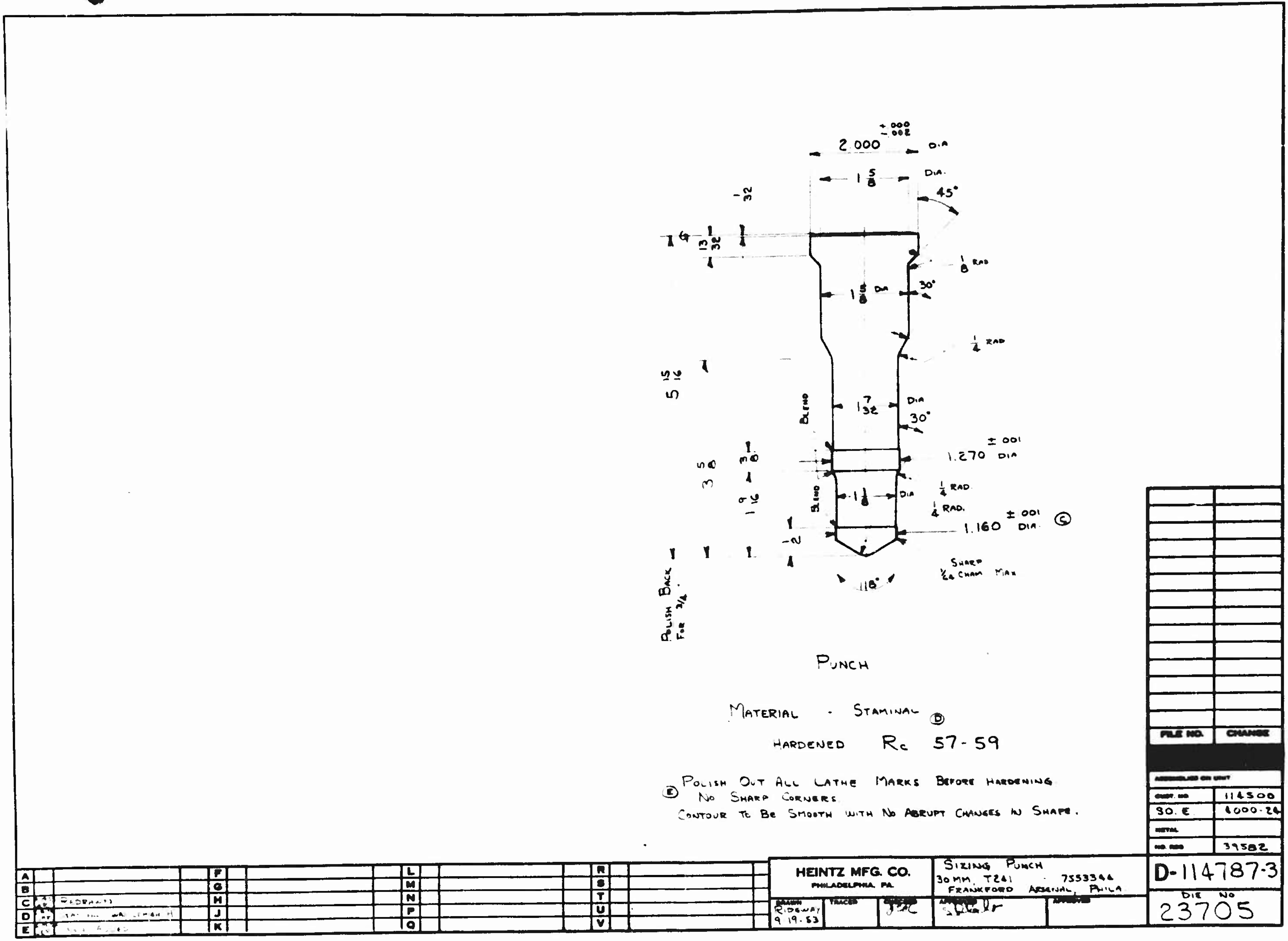
ASSEMBLIES ON UNIT

CUST NO

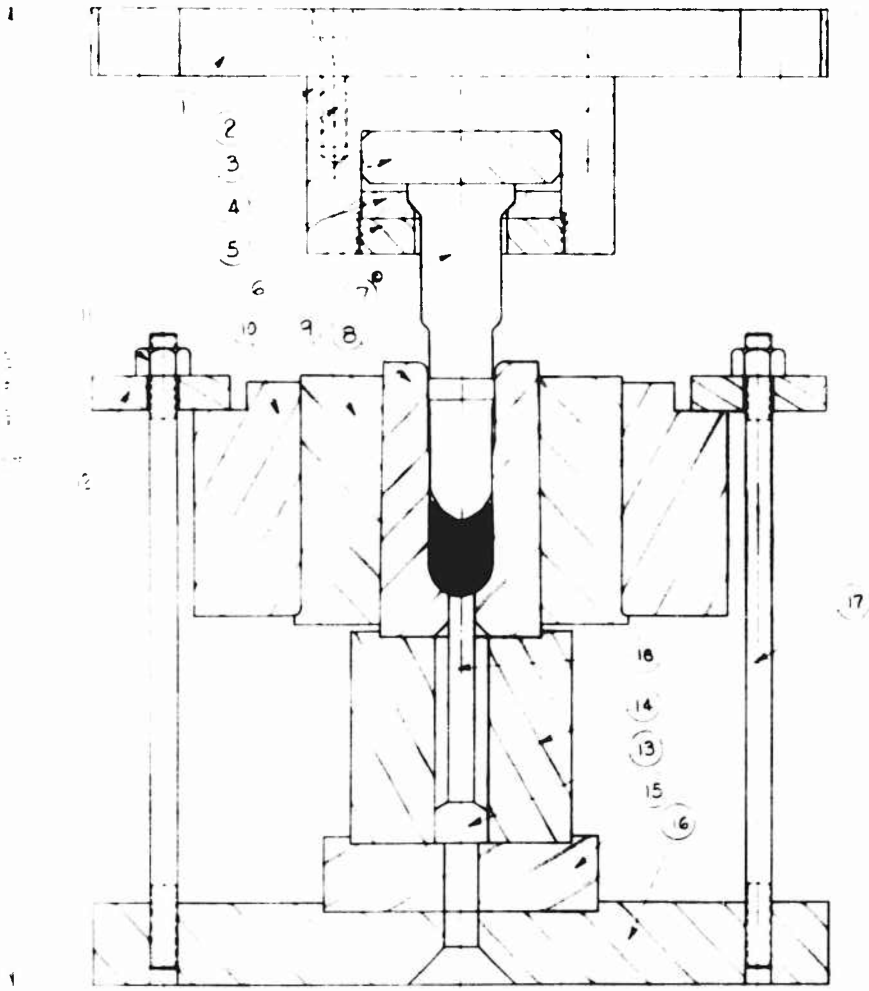
METAL

NO REQ

D-



2.000 +.000 −.002 DIA
1 5/8 DIA.
45°
1/8 RAD
1 5/8 DIA
30°
1/4 RAD
1 7/32 DIA
30°
BLEND
1.270 ±.001 DIA
1/4 RAD.
1 1/8 DIA
1/4 RAD.
1.160 ±.001 DIA. (C)
SHARP 1/64 CHAM MAX
118°
13/32
1/32
5 15/16
3 5/8
3/8
1 9/16
1/2
POLISH BACK FOR 3/4.
PUNCH
MATERIAL - STAMINAL (D)
HARDENED Rc 57-59
(E) POLISH OUT ALL LATHE MARKS BEFORE HARDENING
NO SHARP CORNERS
CONTOUR TO BE SMOOTH WITH NO ABRUPT CHANGES IN SHAPE.
FILE NO.
CHANGE
114500
30. E
1000-24
39582
HEINTZ MFG. CO.
PHILADELPHIA, PA.
SIZING PUNCH
30 MM. T261 7553344
FRANKFORD ARSENAL PHILA
RIDGWAY
9-19-53
D-114787-3
DIE NO
23705



BILL OF MATERIALS

See Note No.	Detail Dwg. No.	Item No.	[illegible]	[illegible]	Rough Sizes
	—	1	1	1	—
	—	2	1	1	—
	—	3	4	4	—
	—	4	1	1	—
	—	5	1	1	—
	—	6	1	1	—
①Ⓐ	D 114783-4	7	1	1	2¼ Dia × 7⅛ Lg. [illegible]
	D 114783-1	8	1		3½ Dia × 8½ Lg. [illegible]
	B 114785-1	9		1	6½ [illegible] × 4⅞ #1-TS
	B 114785-1	10	1	1	4½ Thk × 10⅞ [illegible] B.R.
	—	11	6	6	—
	—	12	1	1	—
	—	13	1	1	—
	—	14	1	1	—
	—	15	1	1	—
	—	16	1	1	—
	—	17	6	6	—
	—	18	1	1	—
①		19	–	—	

NOTE:-

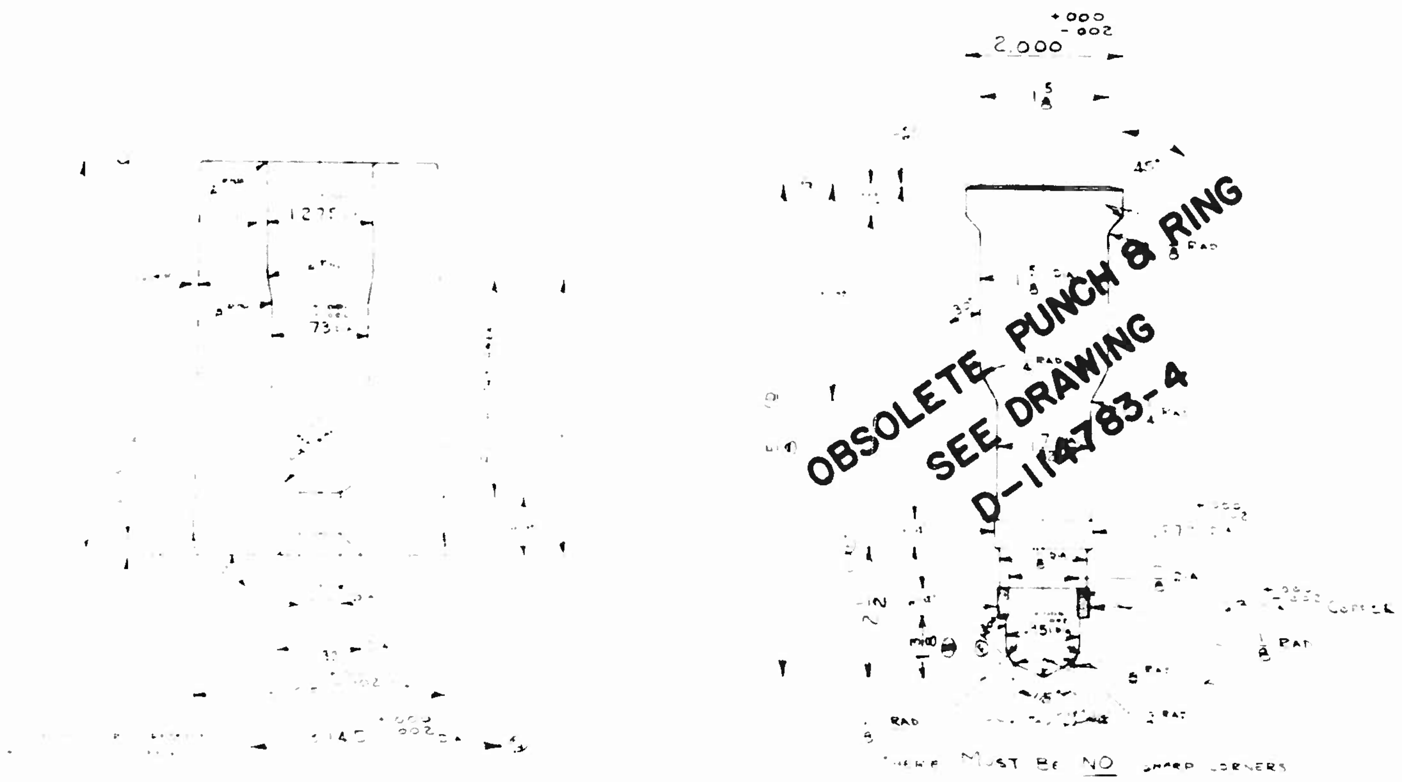
1- Parts Item No. 1, 2, 3, 4, 5, 6, 11, 12, 13, 14, 15, 16, 17, & 18 Are NOT To Be Made For This Die. Use Parts From Die No. 23703 - Dwg. No. B-114785.

HEINTZ MFG. CO.
PHILADELPHIA, PA.

Sizing Die
30 MM, T346 - 86" Rd 7757
Frankford Arsenal, Phila.

B-114783

23701



BUSHING

GRIND

7 PUNCH

MATERIAL

HARDEN

9 PUNCH RING

MATERIAL - COPPER

A		F		L		R		
B	1 3/8 DIAS	G		M		S		
C	2/4 DIAS 1/8	H		N		T		
D		J		P		U		
E		K		Q		V		

FILE NO	CHANGE

ASSEMBLIES ON UNIT

METAL

REG NO 78482

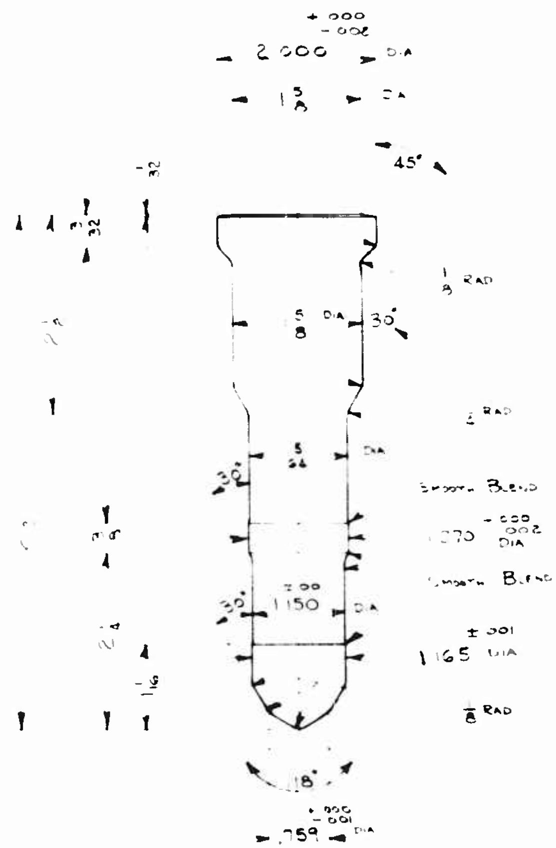
HEINTZ MFG. CO.
PHILADELPHIA, PA

PUNCH & BUSHING (SIZE)
35 MM - T304 SK ... FRANKFORD ARSENAL PHILA

DRAWN	TRACED	CHECKED	APPROVED	APPROVED
RIDGWAY 5-20-53		6-1-53		

D-14783

DIE NO 23701



(7) PUNCH

MATERIAL - STA... (A)

HARDEN Rc 57 - 59

POLISH OUT ALL LATHE MARKS BEFORE HARDENING

#5

FILE NO.	CHANGE

ASSEMBLIES ON UNIT

CUST NO

METAL

NO REQ

HEINTZ MFG. CO.
PHILADELPHIA, PA

PUNCH — SIZE
30 MM T304 — ST. FSA 7757
FRANKFORD ARSENAL, PHILA

DRAWN: RIDGWAY 10-18-53 | TRACED | CHECKED | APPROVED | APPROVED

D-11478 3-4

DIE NO
23701

A		F		L		R	
B		G		M		S	
C		H		N		T	
D		J		P		U	
E		K		Q		V	

7. <u>SURFACE TREAT SIZED PIECE</u>

This operation was identical with Operation #5.

This surface treatment was eliminated on a test group of pieces, but the results indicated that the residual Foscoat on the sized pieces was not sufficient to withstand the first backward extrusion operation.

8. FIRST BACKWARD EXTRUSION

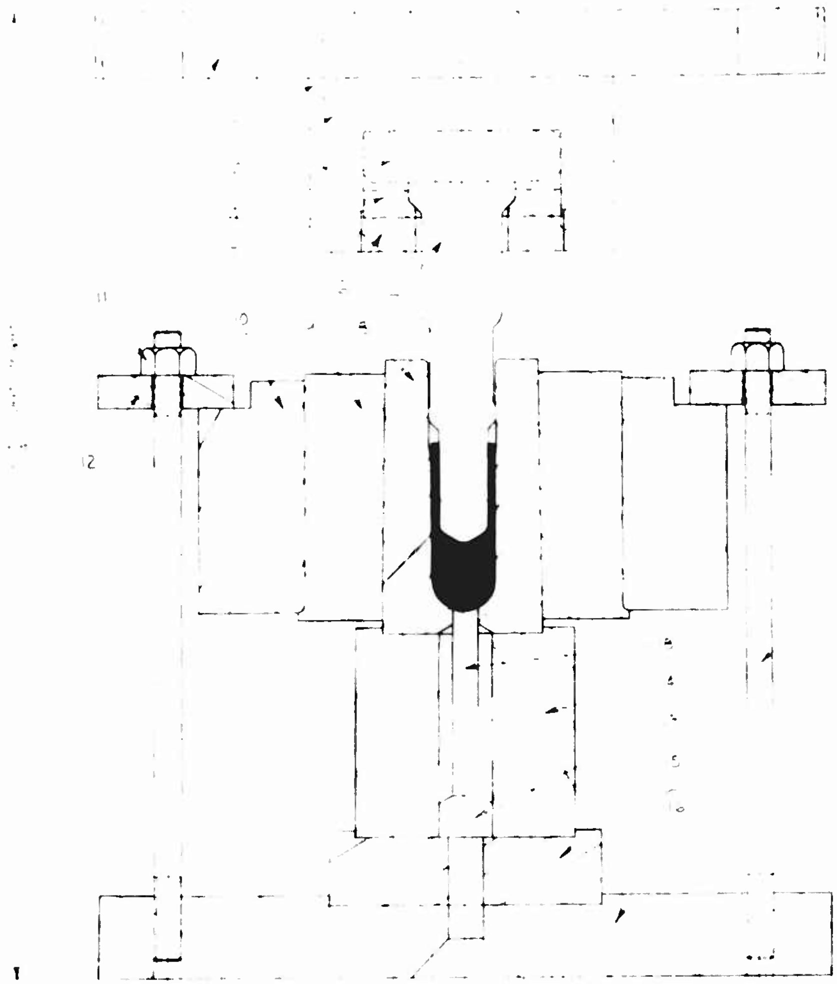
The complete tooling required to perform this operation is shown on Dwg #114784 and #114788 on the pages immediately following this text.

This die formed the .945" inside diameter of the shell bodies. The Foscoated sized piece was placed in the die and the punch forced the piece down further into the die until a stress level was reached in the piece which balanced the vertical loads. Then the metal under the punch flowed upward through the annular orifice between punch and die.

Considerable care had to be exercised in aligning this die and the variation in wall thickness of the extruded piece had tc be checked to assure that it was within the allowable tolerance.

This piece should form the cavity with the desired shape as shown on Dwg #122717 and #122716.

Considerable trouble in this respect was experienced with both shell bodies in that the piece still did not fill out the hemispherical cavity of the die. This made it extremely difficult to measure the metal remaining in the unextruded section. This difficulty

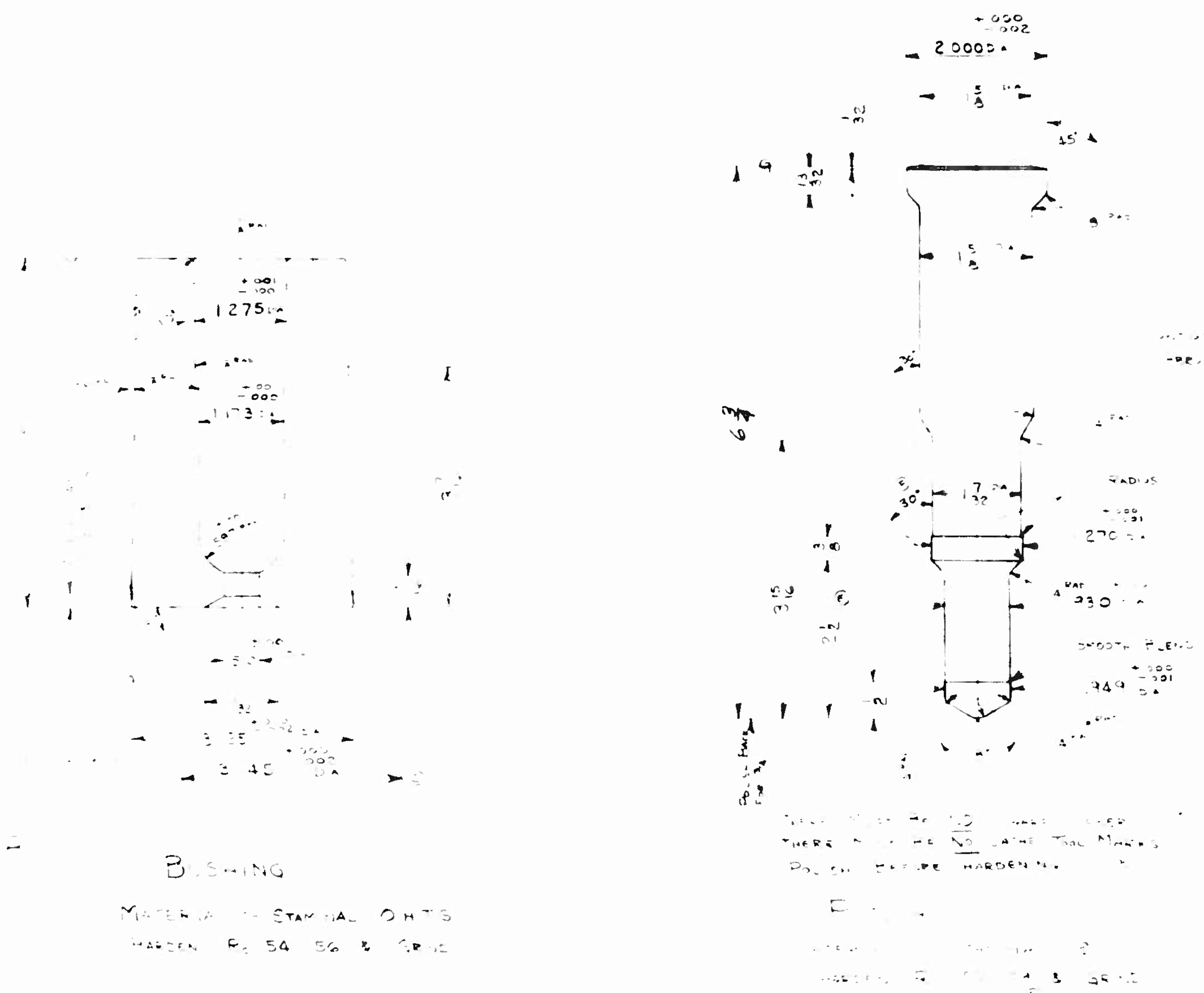


A		F		L		R		W		AB		AG	
B		G		M		S		X		AC		AH	
C		H		N		T		Y		AD		AJ	
D		J		P		U		Z		AE		AK	
E		K		Q		V		AA		AF		AL	

FILE NO | CHANGE

HEINTZ MFG. CO.
PHILADELPHIA PA.

B- -



FILE NO.	CHANGE
ASSEMBLIES ON UNIT	
NO	114500
	4000-11
METAL	
NO	37836

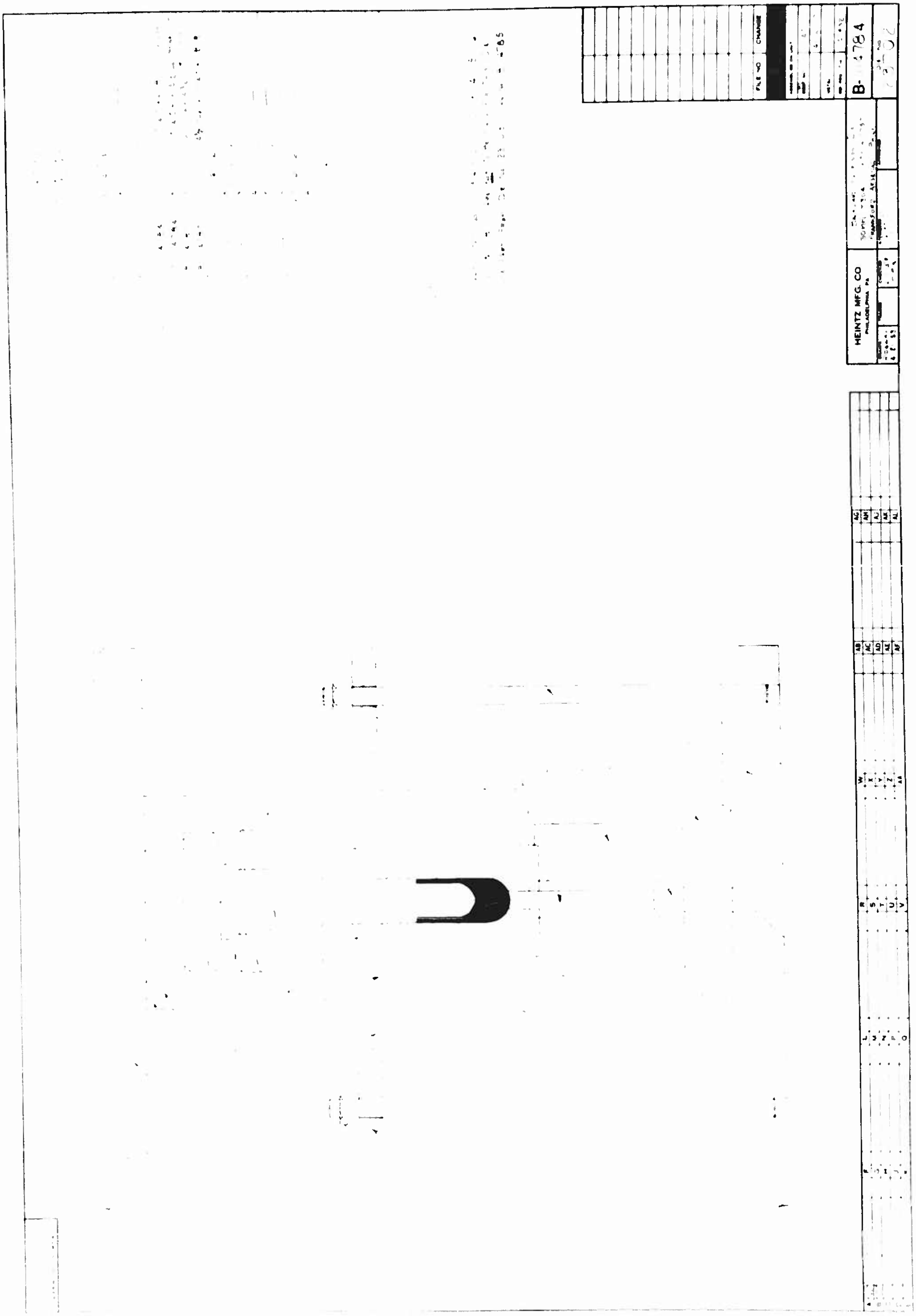
HEINTZ MFG. CO.
PHILADELPHIA, PA

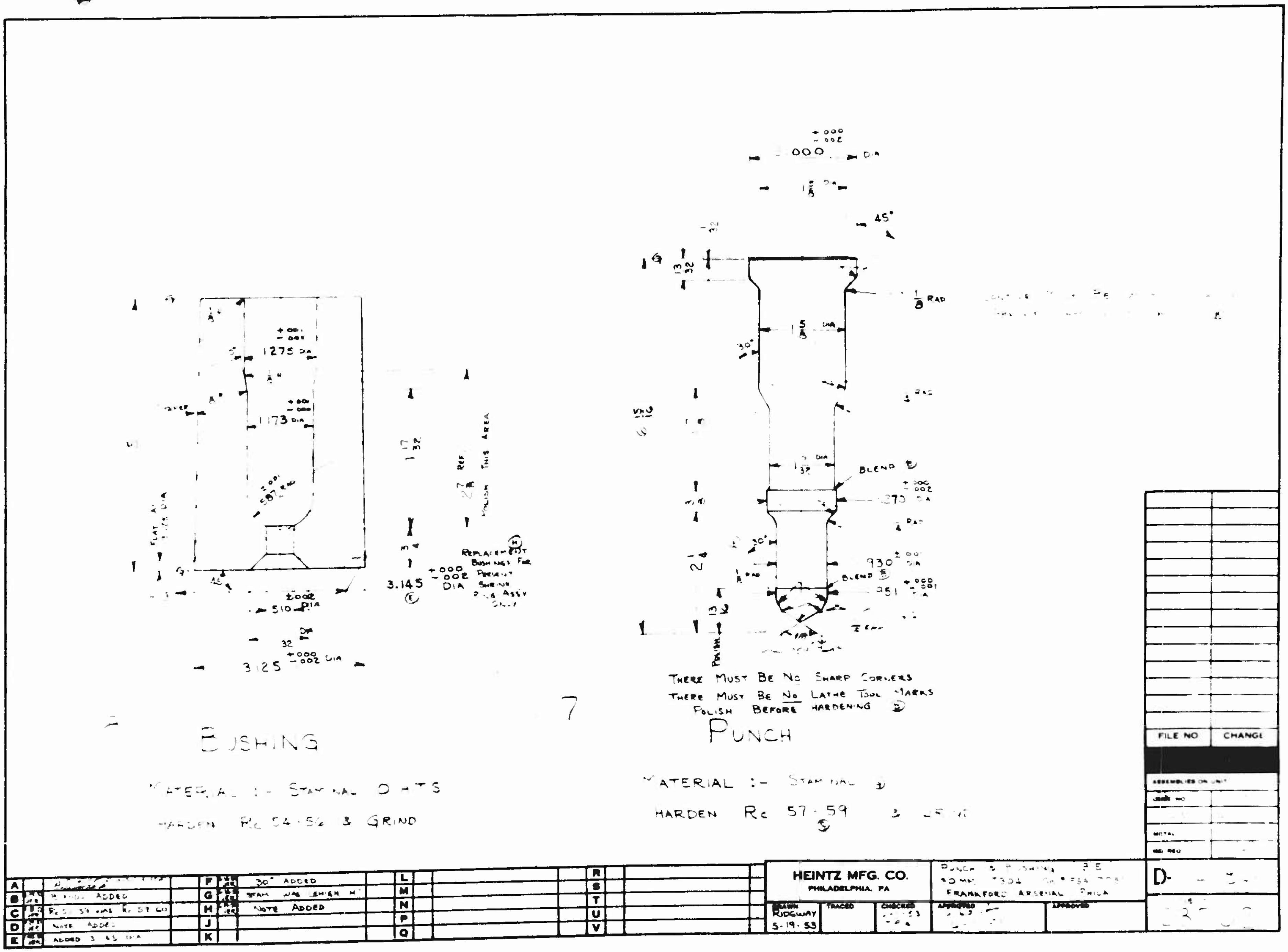
PUNCH & BUSHING (BE)
30 MM - T241 Dwg No. 7553344
FRANKFORD ARSENAL PHILA.

D-114788-1

DIE NO. 23706

DRAWN RIDGWAY 8-21-53 | TRACED | CHECKED | APPROVED | APPROVED


HEINTZ MFG. CO
PHILADELPHIA PA
FILE NO
CHANGE


BUSHING
HARDEN Rc 54-56 & GRIND
PUNCH
THERE MUST BE NO SHARP CORNERS
THERE MUST BE NO LATHE TOOL MARKS
POLISH BEFORE HARDENING
HARDEN Rc 57-59
REPLACEMENT BUSHINGS FOR PRESENT SHEAR ASSY
POLISH THIS AREA
30° ADDED
NOTE ADDED
HEINTZ MFG. CO.
PHILADELPHIA, PA
FRANKFORD ARSENAL PHILA
DRAWN RIDGWAY 5-19-53
TRACED
CHECKED
APPROVED
FILE NO
CHANGE
7

9. SURFACE TREAT

The chemical aspects of this operation were identical with Operation #5.

However, the deep impression formed by backward extrusion tended to air lock when the pieces were being treated unless provision was made to rack the pieces in a manner that would allow the air to escape from the cavity as the particular solution entered it.

In actual practice this was accomplished by placing the pieces in baskets that were designed to rotate about 30° on either side of the level position.

10. FINAL BACKWARD EXTRUSION

This operation is similar in principle for both shell but differed in both depth and severity from the thin bottom .770" diameter T304 body to the thick bottom 5/8" diameter T241 body. The results, for this reason, differed considerably.

The force required to form the .770" inside diameter of the T304 shell, coupled with the extreme depth of penetration of the punch, forced the metal to fill completely the lower die cavity. The lighter vertical load generated when forming the 5/8" inside diameter of the T241 shell was not sufficient to cause the metal to flow completely into the cavity. This was the reason for the deviation which allowed a 9/16" diameter flat to be machined across the otherwise hemispherical surface of the T241 body.

The tools to perform this operation are shown on Dwg #B-114785 and #B-114789.

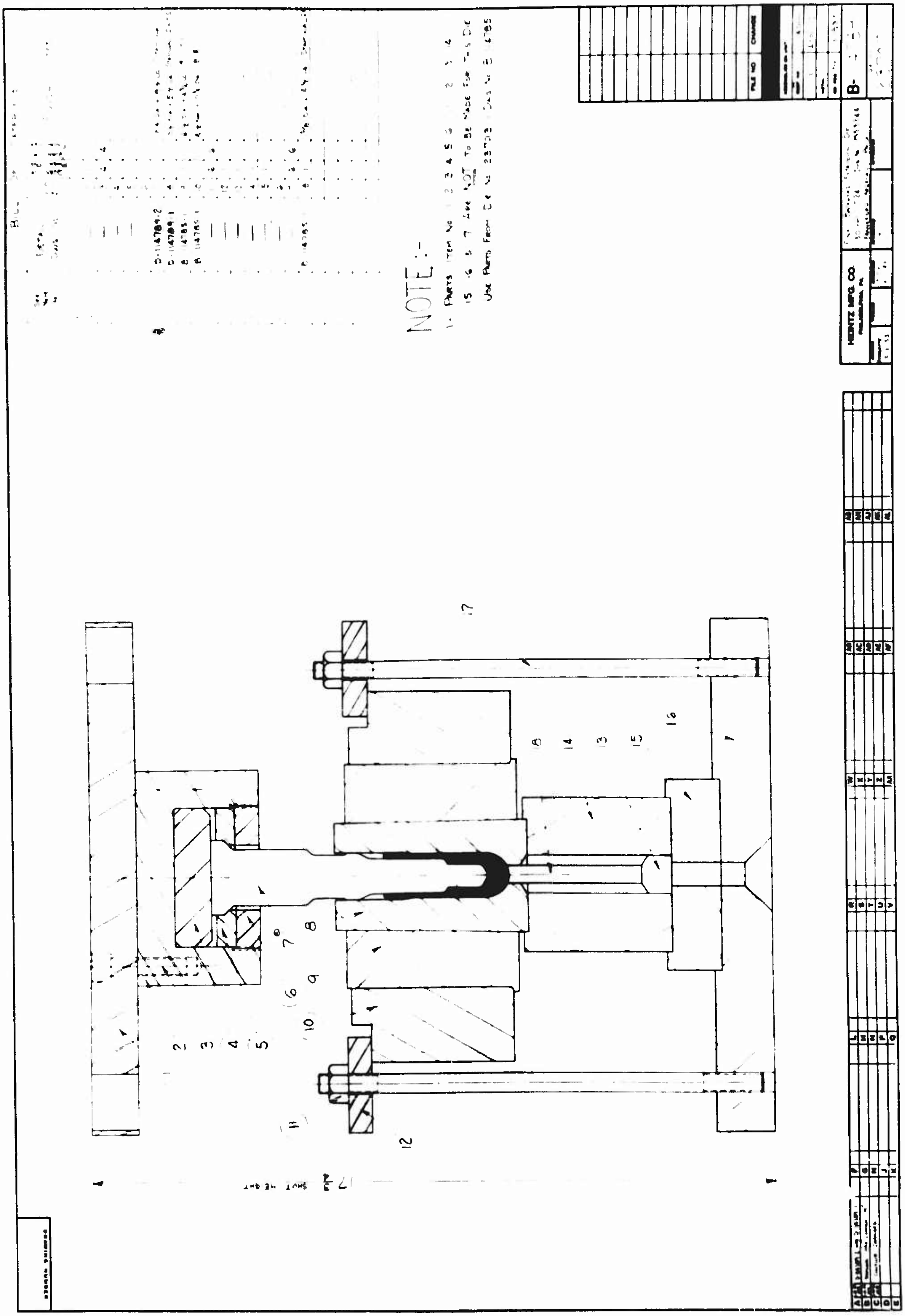
A 100 ton mechanical single point Clearing Machine Corporation press was used. The actual tonnages required were 67 tons for the T304 shell and 46 tons for the T241 shell.

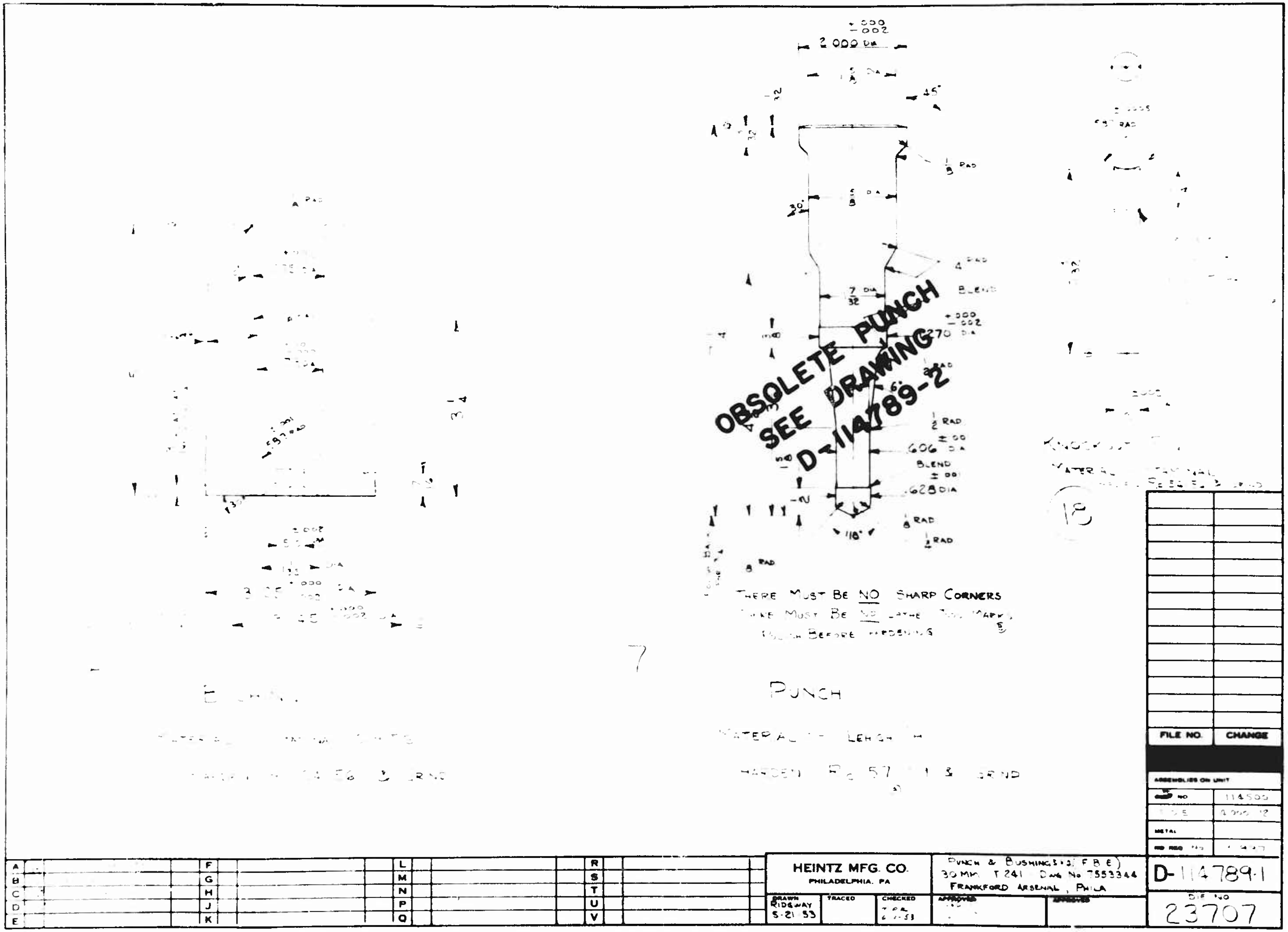
Reference to the sequence Dwg #E-112717 and #E-112716

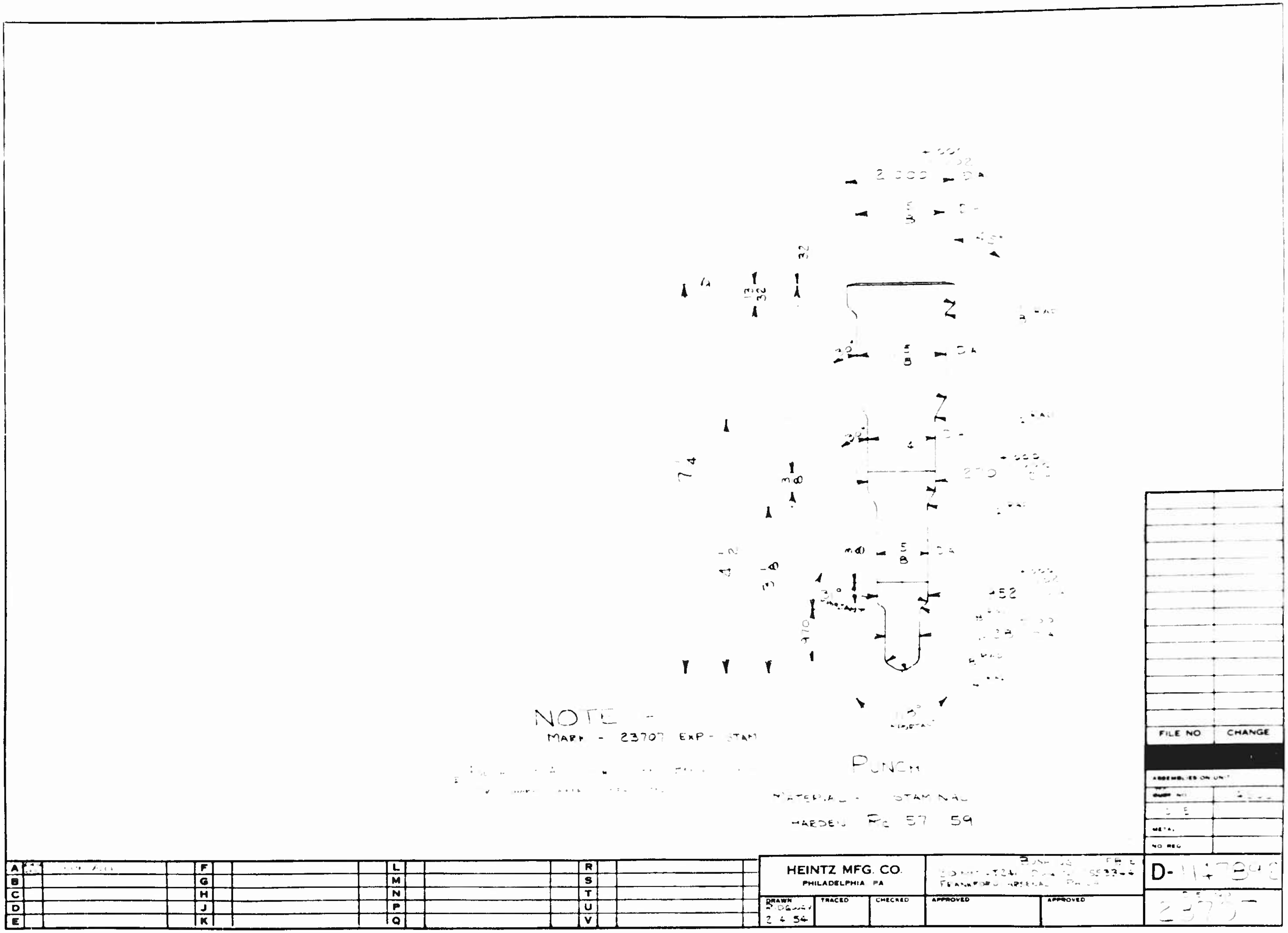
FINAL BACKWARD EXTRUSION (Cont.)

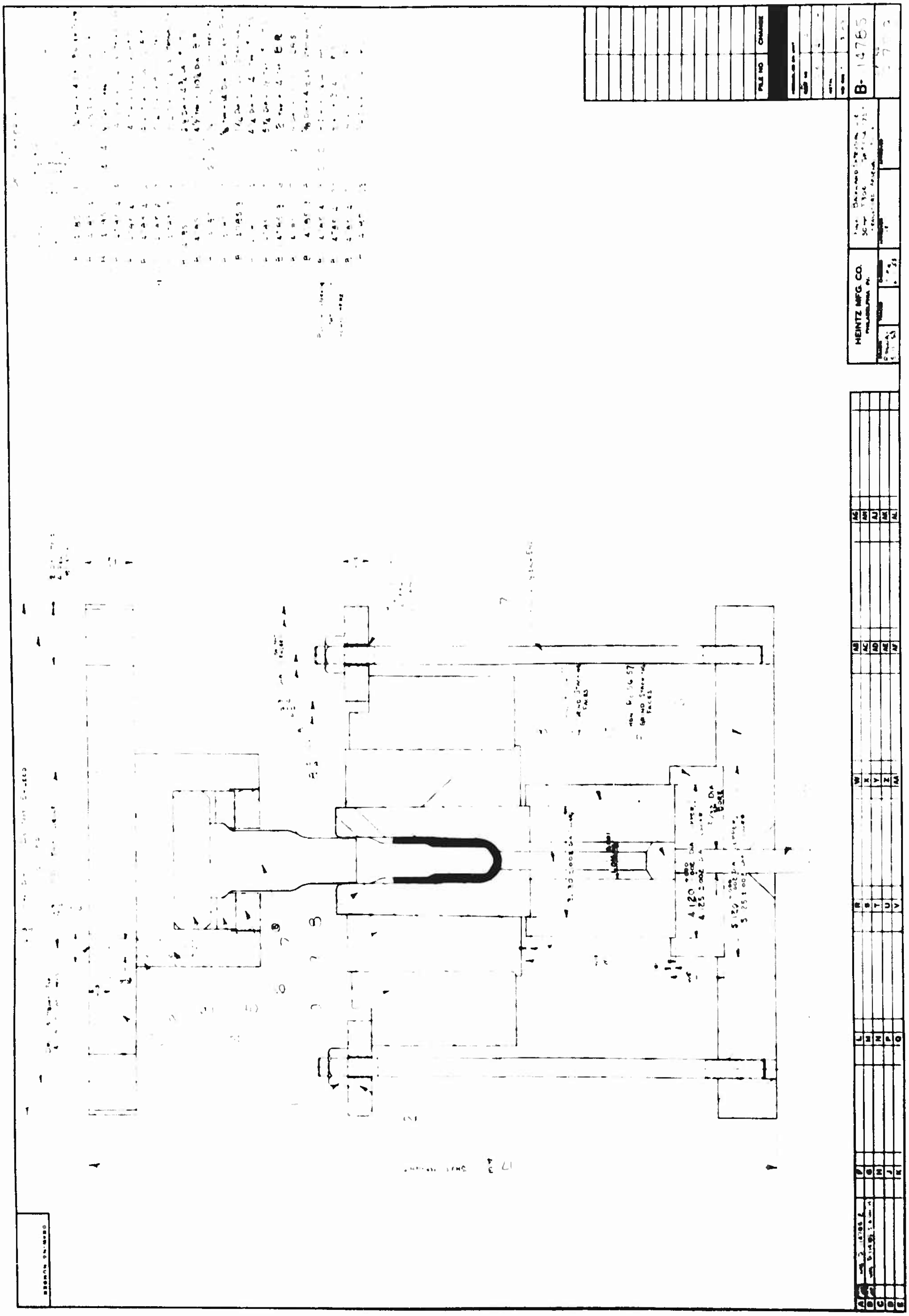
indicates if the bottom thickness in the first backward extrusion was not held within extremely close tolerances, either too much or too little metal would have been displaced by the punch during the second backward extrusion. This would have varied the position of the shoulder in the cavities of the bodies more than the allowable tolerance. Since there was considerable variation in the degree to which the metal filled the hemispherical die cavity during the first backward extrusion, it was at first impossible to maintain the position of the shoulder.

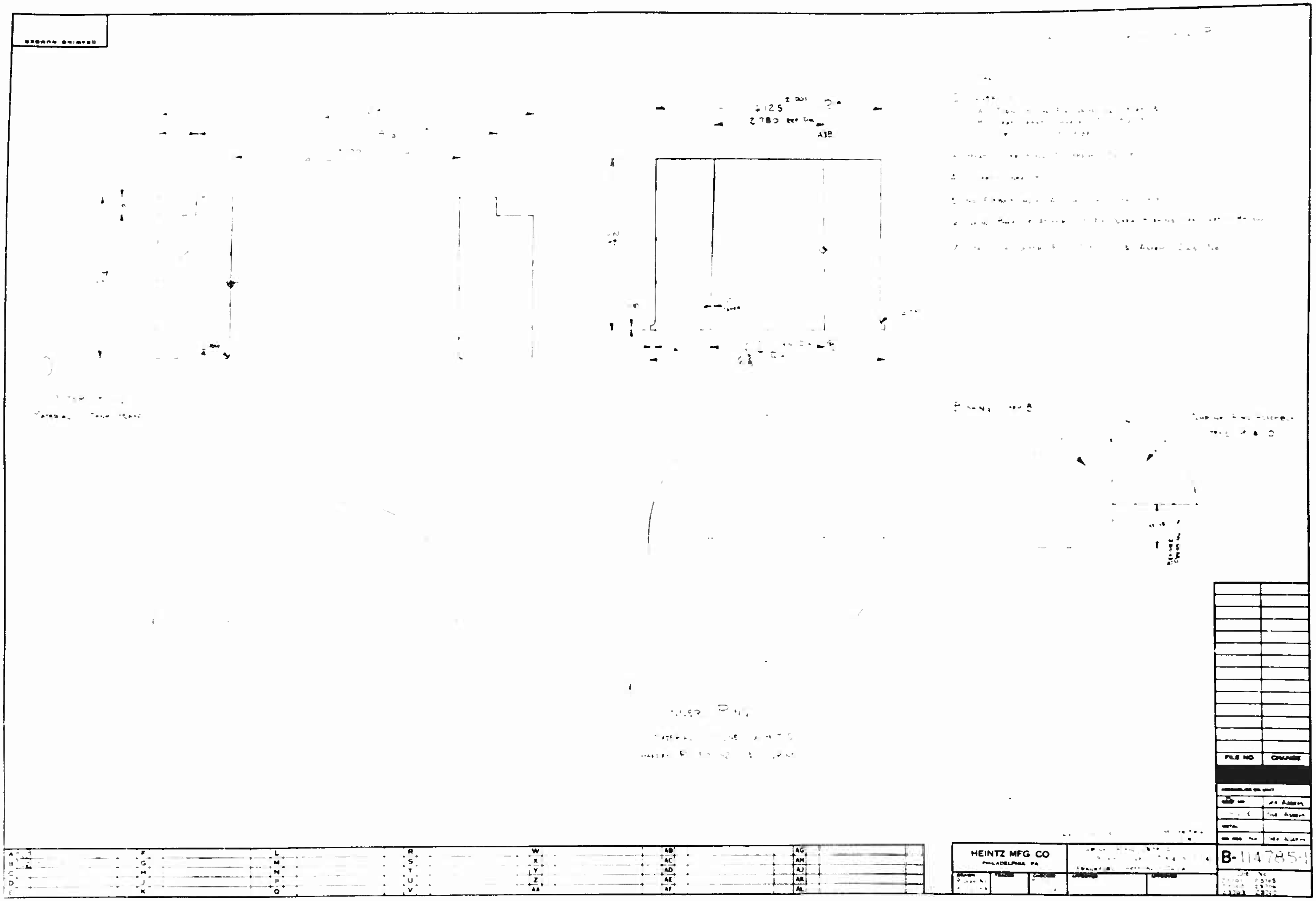
This problem was solved by making a final backward extrusion punch as shown on Dwg #D-114789-2 and forming not only the small lower inside diameter of the shell in this operation, but also a portion of the larger upper inside diameter. In this manner the position of the shoulder was accurately controlled.

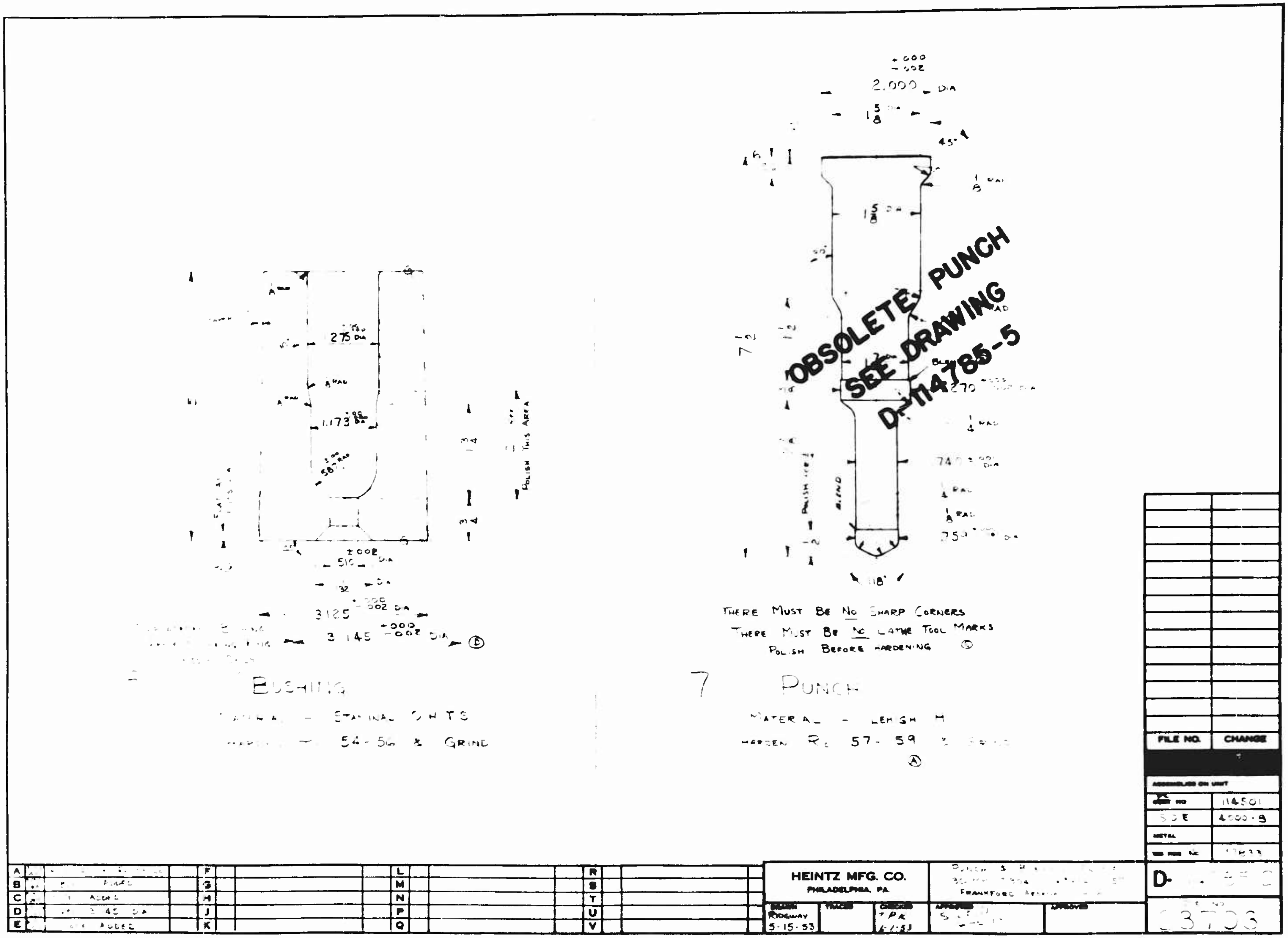

NOTE :-
HEINTZ MFG. CO.
PHILADELPHIA, PA.

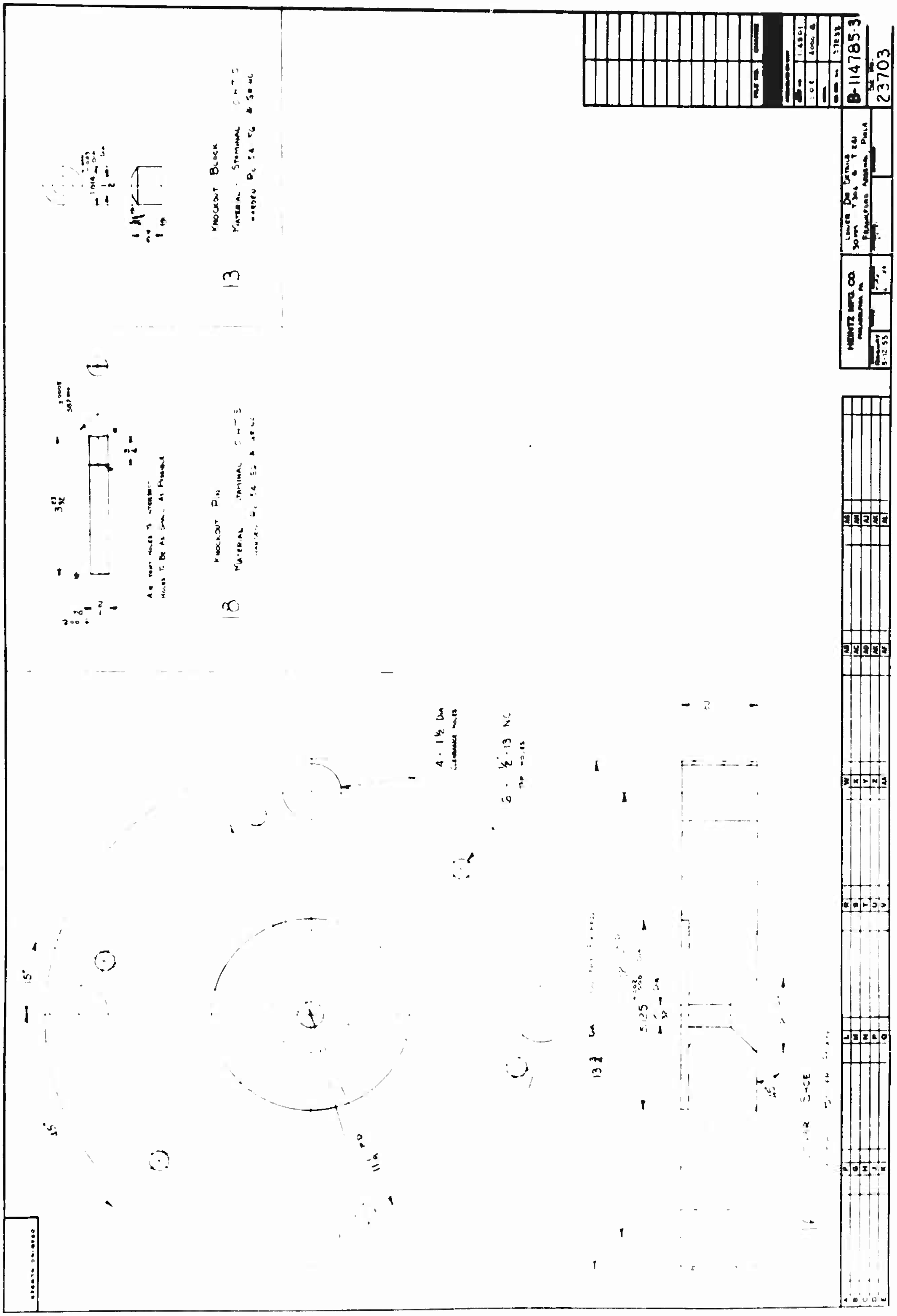

OBSOLETE PUNCH
SEE DRAWING
D-114789-2
2.000 DIA
+.000
-.002
45°
30°
7/32 DIA
.270 DIA
.606 DIA
.628 DIA
BLEND
1/2 RAD
118°
THERE MUST BE NO SHARP CORNERS
PUNCH
18
FILE NO.
CHANGE
ASSEMBLIES ON UNIT
METAL
HEINTZ MFG. CO.
PHILADELPHIA, PA
PUNCH & BUSHINGS FRANKFORD ARSENAL, PHILA
DRAWN RIDGWAY 5-21-53
TRACED
CHECKED
APPROVED
D-114789-1
DIE NO
23707


NOTE -
MARK - 23707 EXP - STAM
PUNCH
MATERIAL - STAM NAL
HARDEN Rc 57 59
HEINTZ MFG. CO.
PHILADELPHIA PA
DRAWN
2 4 54
TRACED
CHECKED
APPROVED
APPROVED
FILE NO
CHANGE
ASSEMBLIES ON UNIT
METAL
NO REQ

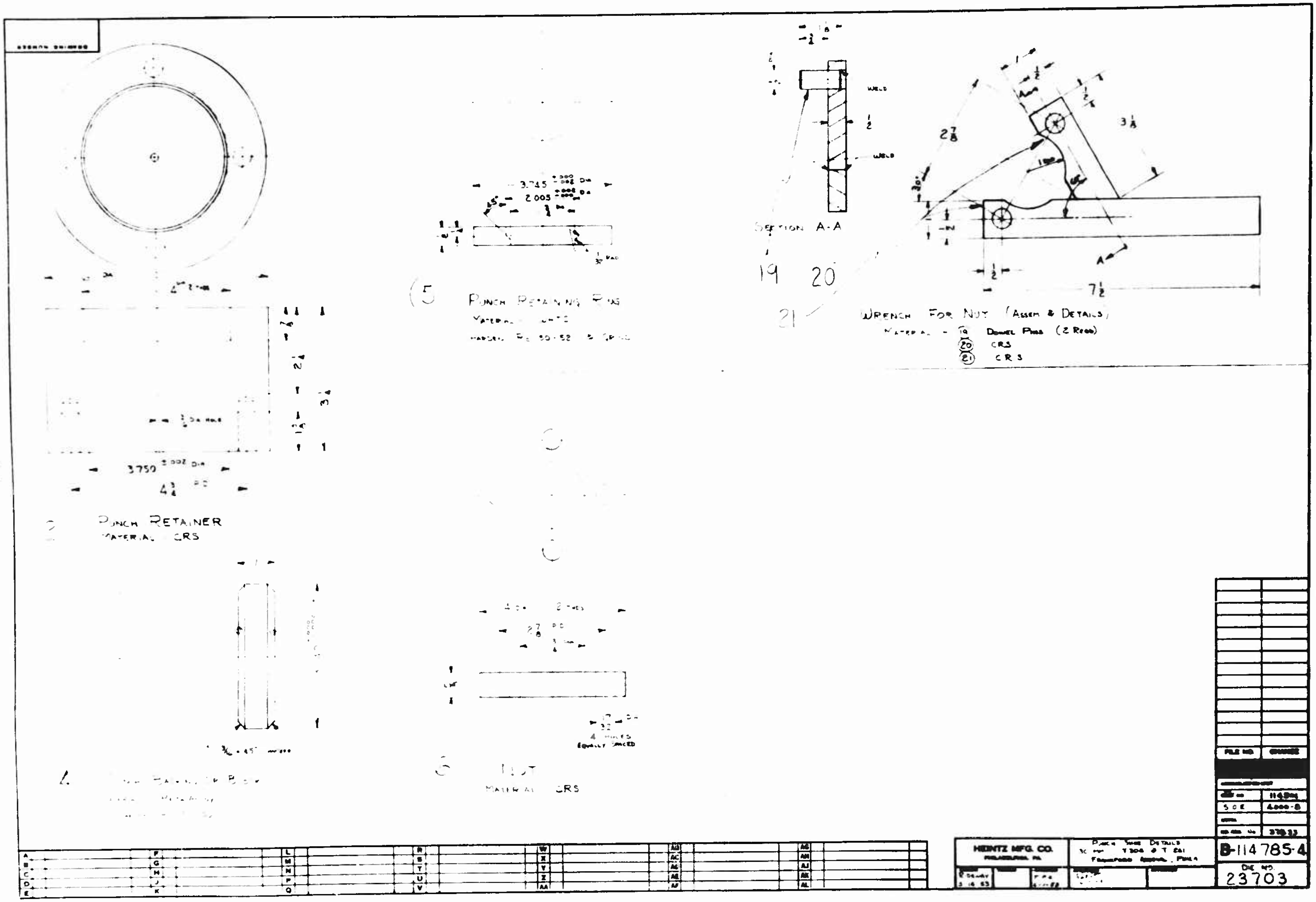

HEINTZ MFG. CO.
PHILADELPHIA PA.
FILE NO
CHANGE
B- 14785

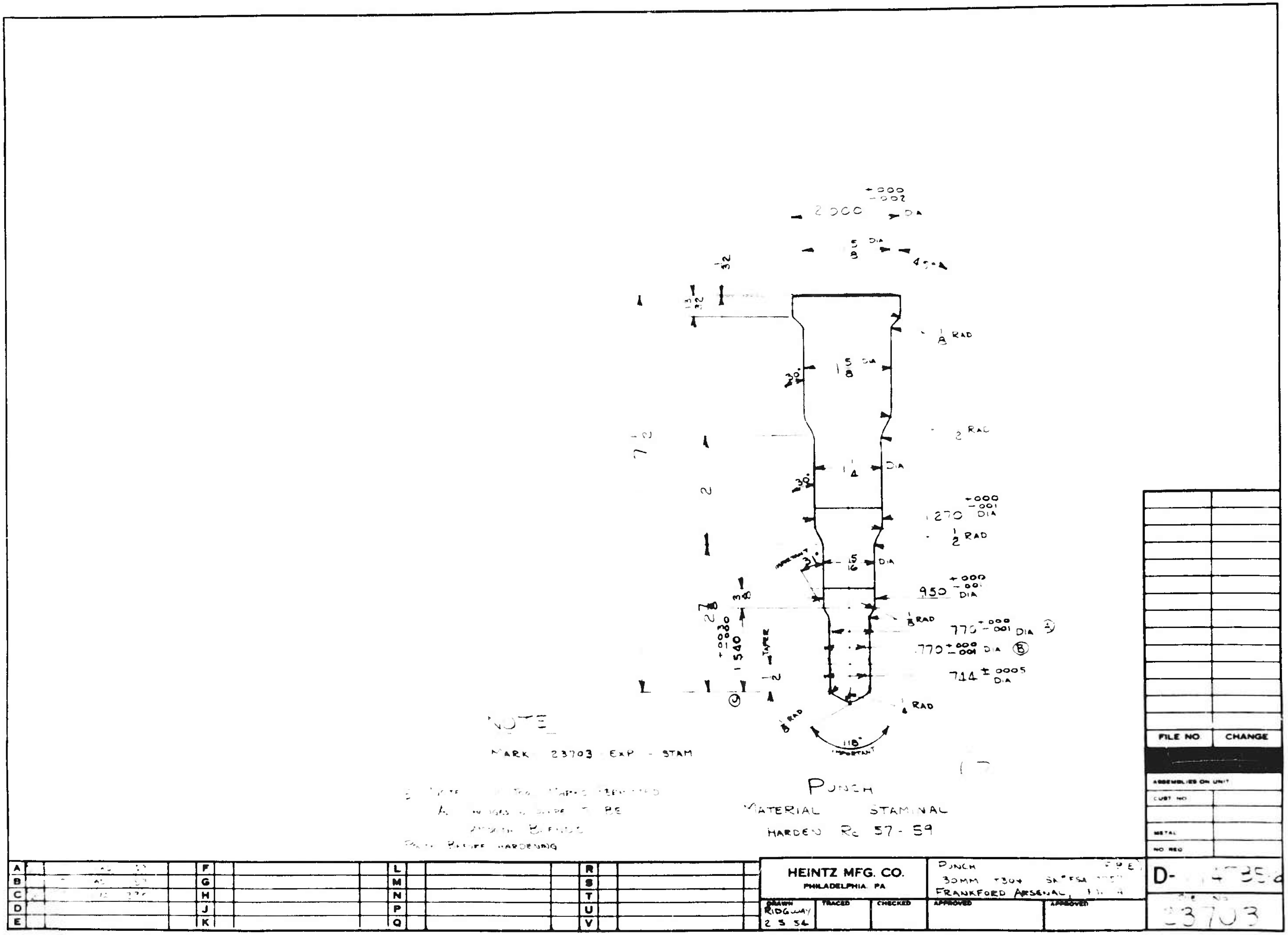

FILE NO
CHANGE
HEINTZ MFG CO
PHILADELPHIA PA


OBSOLETE PUNCH
SEE DRAWING
D-114785-5
BUSHING
54 - 56 & GRIND
3.125
3.145 DIA
.275 DIA
1.173 DIA
.510 DIA
POLISH THIS AREA
PUNCH
MATERIAL - LEHIGH H
HARDEN Rc 57 - 59
2.000 DIA
1 5/8 DIA
45°
1/8 RAD
1 5/8 DIA
.1270
1/4 RAD
.740 DIA
1/4 RAD
1/8 RAD
.750 DIA
118°
7 1/2
BLEND
POLISH
THERE MUST BE NO SHARP CORNERS
THERE MUST BE NO LATHE TOOL MARKS
POLISH BEFORE HARDENING
FILE NO.
CHANGE
114501
4000-9
HEINTZ MFG. CO.
PHILADELPHIA, PA.
FRANKFORD ARSENAL
RIDGWAY
5-15-53
7PA
6-1-53
D-



15°
15°
11½ PD
4 - 1½ Dia
Clearance Holes
6 - ½-13 NC
Tap Holes
13¾ Dia
5.125
18
Knockout Pin
Material
13
Knockout Block
Material
HEINTZ MFG. CO.
Philadelphia, Pa.
Lower Die Details
Frankford Arsenal Phila
B-114785-3
23703


PUNCH RETAINER
MATERIAL CRS
PUNCH RETAINING RING
SECTION A-A
WRENCH FOR NUT (ASSEM & DETAILS)
MATERIAL - 19 DOWEL PINS (2 REQD)
20 CRS
21 CRS
NUT
MATERIAL CRS
HEINTZ MFG. CO.
B-114785-4
DIE NO.
23703


NOTE
MARK 23703 EXP - STAM
PUNCH
MATERIAL STAMINAL
HARDEN Rc 57 - 59
HEINTZ MFG. CO.
PHILADELPHIA PA
FRANKFORD ARSENAL
DRAWN
RIDGWAY
2 5 56
TRACED
CHECKED
APPROVED
FILE NO
CHANGE
ASSEMBLIES ON UNIT
CUST NO
METAL
NO REQ
23703
118° IMPORTANT
2.000 +.000 −.002 DIA
1.270 +.000 −.001 DIA
.950 +.000 −.001 DIA
.770 +.000 −.001 DIA
.714 ± .0005 DIA
1.540 +.003 −.000
1/8 RAD
1/2 RAD
1/4 RAD
30°
TAPER

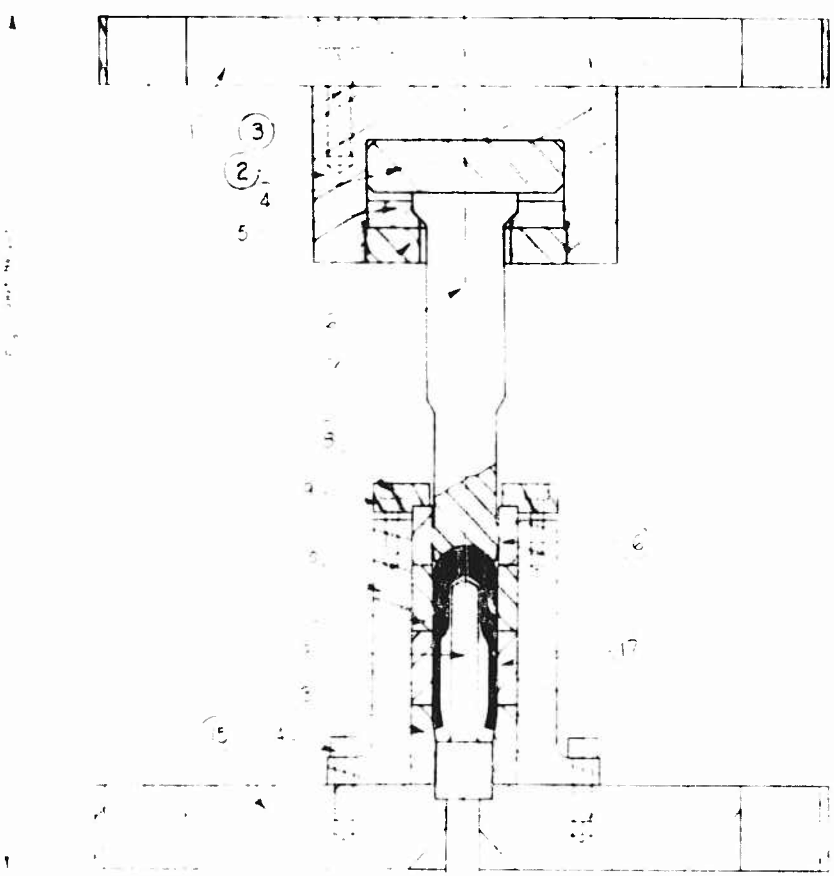
11. NOSING

The previous press operation worked only the base portion of the shell leaving the Foscoat on the open end undisturbed. Therefore, no further lubrication was needed to perform this operation.

The final backward extruded piece was placed in the die with its open end down. A hemispherically concave punch forced the shell into the die which formed the nose shape and sized the outside diameter.

The tools necessary to perform this operation are shown on Dwg #114786 and #114790.

The die was run on a 100 ton Clearing Machine Corporation single point press. The actual force required was approximately ten tons.



Dwg. No.	Item No.	Description
	2	
	3	
	4	
	5	
	6	
D-114790-2	7	2⅝ Dia × 7⅞ Lg. Steel
B-114790	8	[illegible] Cap Screw
B-114790-1	9	3⅜ Dia × [illegible] CRS
B-114790-1	10	5⅛ Dia × 5 [illegible] CRS
D-114790-2	11	2⅝ Dia × 1½ Lg. #4 TS
B-114790-1	12	[illegible] TS
D-114790-2	13	2⅝ Dia × 1¾ Lg. #4 TS
B-114790	14	[illegible] Cap Screw
B-114790-1	15	[illegible] BR
D-114790-2	16	2⅝ Dia × 1¾ Lg. #4 TS
D-114790-2	17	2⅝ Dia × [illegible] #4 TS

NOTE -

1. Parts Item No. 1 2 3 4 5 & 6 Are NOT To Be Made For This Die
2. Use Parts From Die No. 23708 - Dwg. No. B-114785

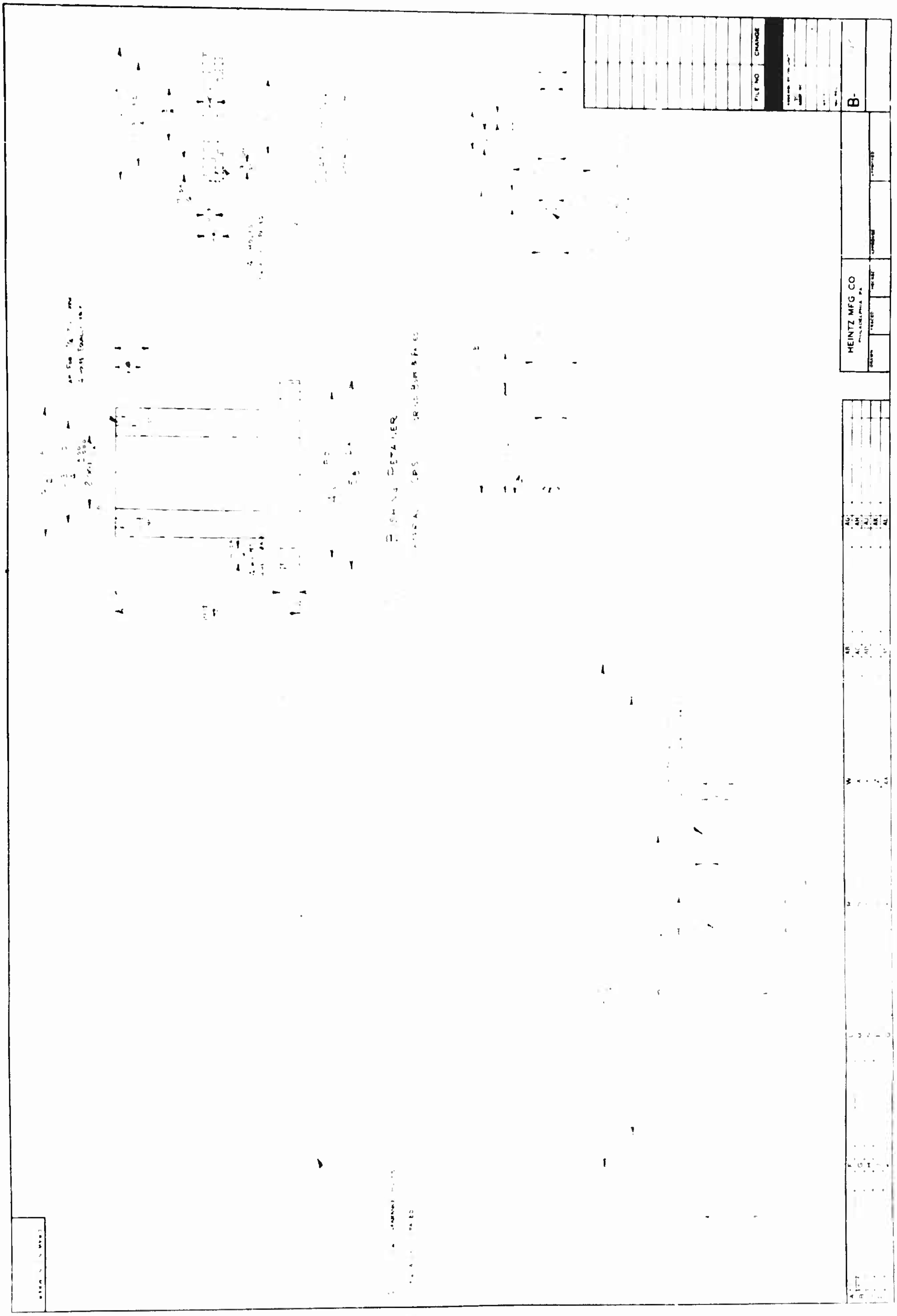
HEINTZ MFG. CO.
PHILADELPHIA, PA.

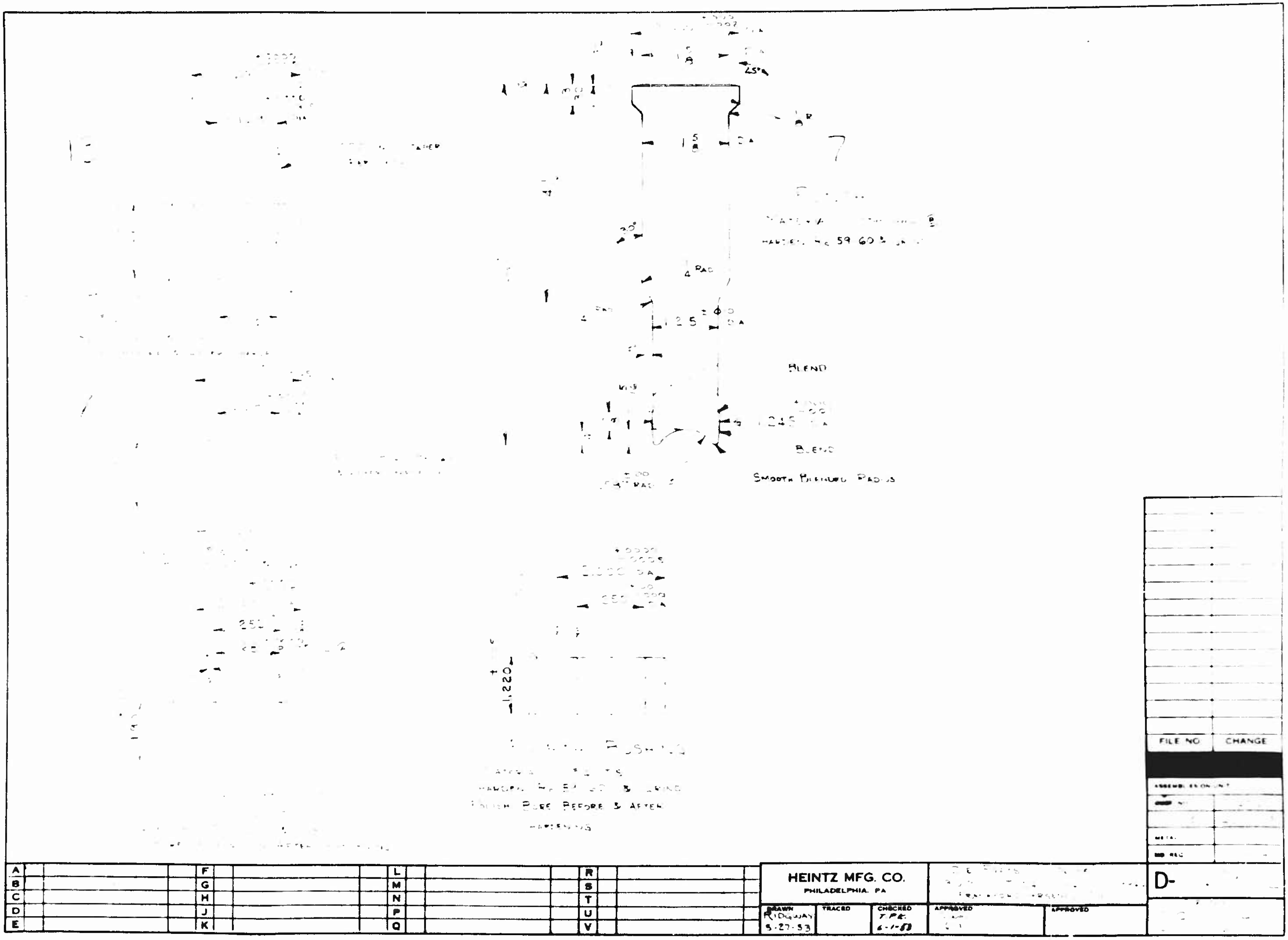
Sizing Die
30 mm T74
Frankford Arsenal, Phila.

114800
S.O.E. 6000-13

B-114790

Die No. 23708


HEINTZ MFG CO
PHILADELPHIA PA
FILE NO
CHANGE
B-


HEINTZ MFG. CO.
PHILADELPHIA, PA
DRAWN
RIDGWAY
5-27-53
TRACED
CHECKED
T.P.K.
6-1-53
APPROVED
FILE NO.
CHANGE
D-
BLEND
SMOOTH BLENDED RADIUS
HARDEN RC 59 60
1.220
FINISH BORE BEFORE & AFTER
HARDENING
A
B
C
D
E
F
G
H
J
K
L
M
N
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R
S
T
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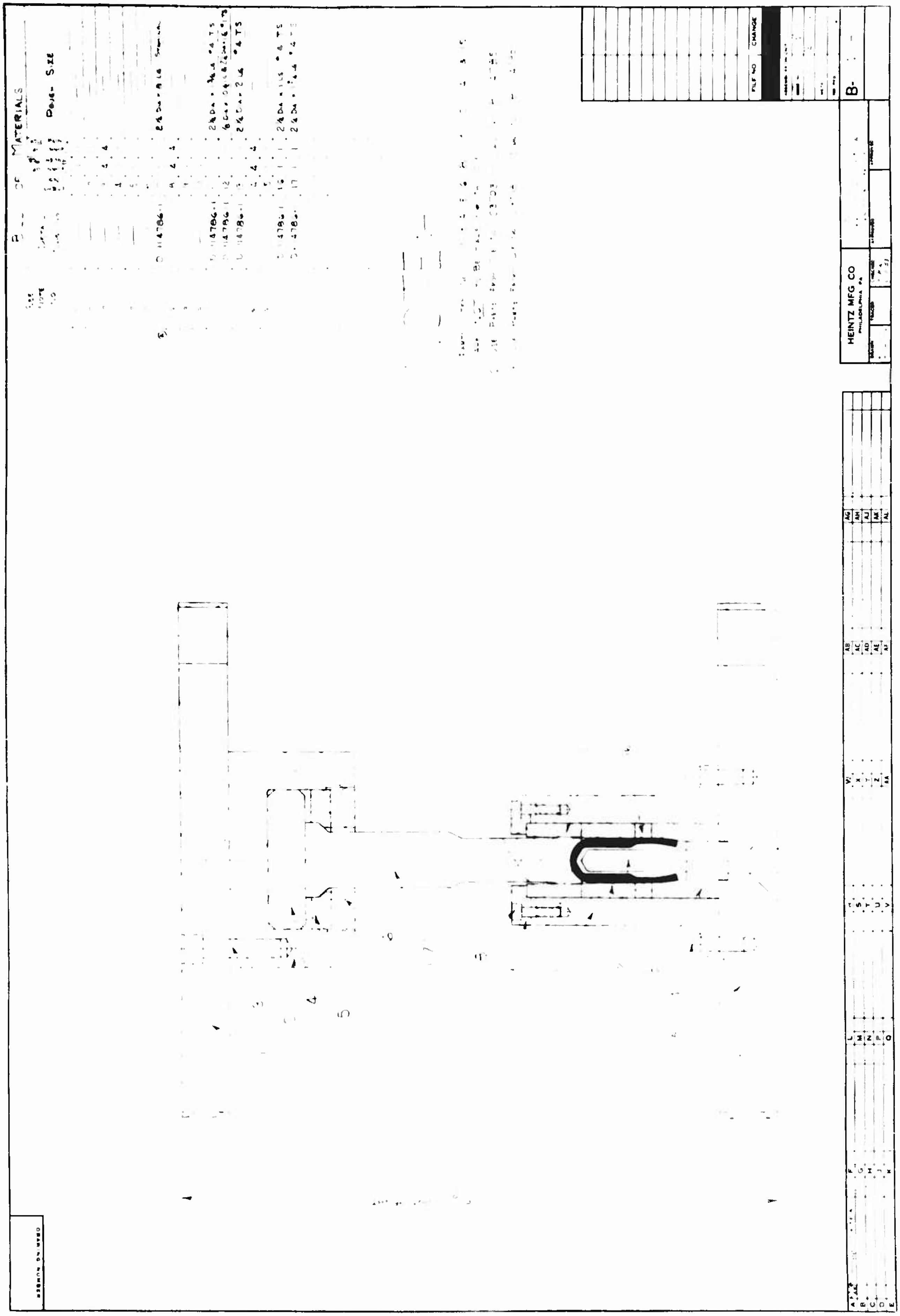
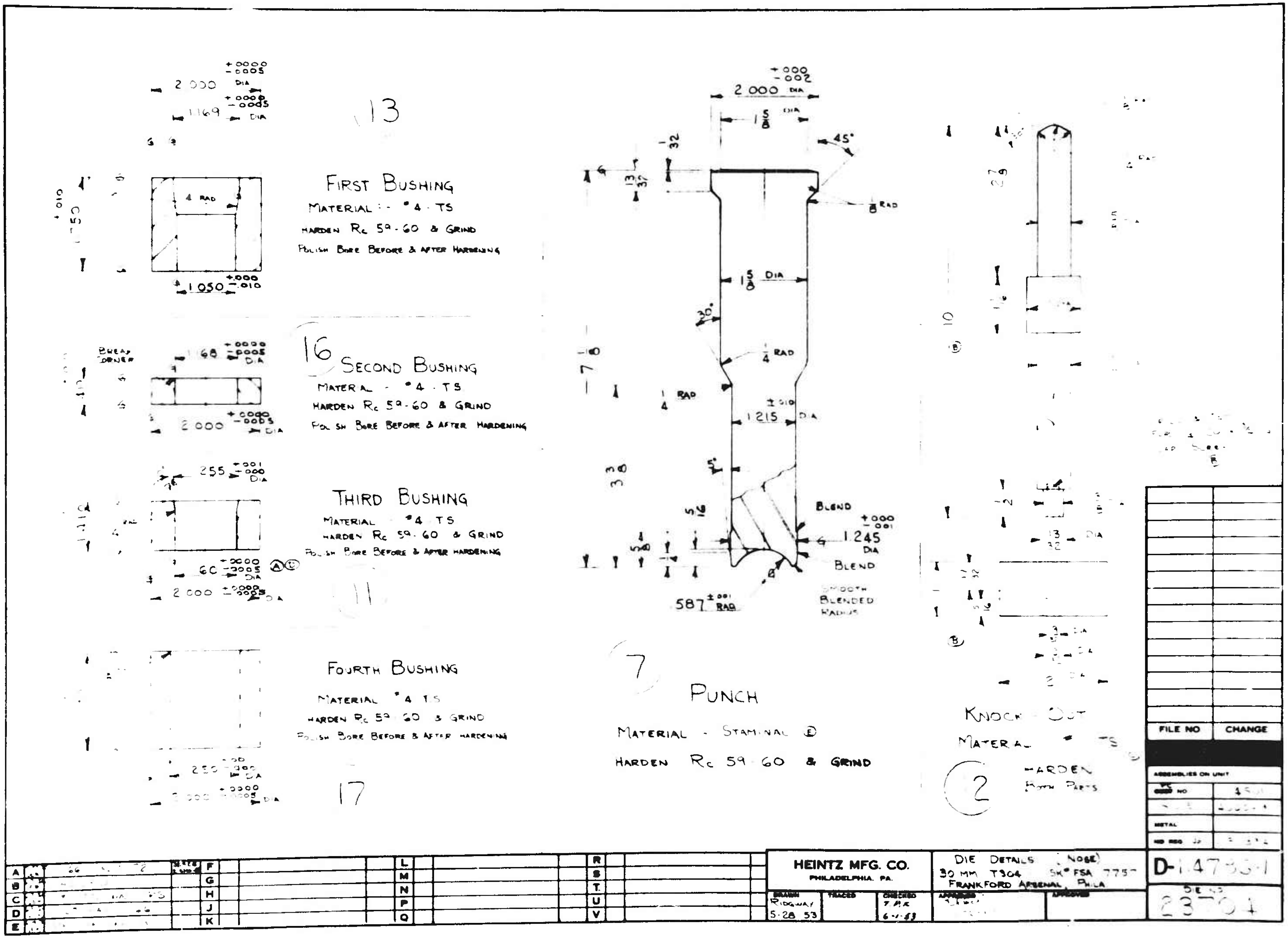
V


HEINTZ MFG CO
PHILADELPHIA PA
MATERIALS



FIRST BUSHING
MATERIAL - #4 TS
HARDEN Rc 59-60 & GRIND
POLISH BORE BEFORE & AFTER HARDENING
SECOND BUSHING
MATERIAL - #4 TS
HARDEN Rc 59-60 & GRIND
POLISH BORE BEFORE & AFTER HARDENING
THIRD BUSHING
MATERIAL #4 TS
HARDEN Rc 59-60 & GRIND
POLISH BORE BEFORE & AFTER HARDENING
FOURTH BUSHING
MATERIAL #4 TS
HARDEN Rc 59-60 & GRIND
POLISH BORE BEFORE & AFTER HARDENING
PUNCH
MATERIAL - STAMINAL
HARDEN Rc 59-60 & GRIND
KNOCK-OUT
HARDEN BOTH PARTS
BLEND
SMOOTH BLENDED RADIUS
FILE NO
CHANGE
ASSEMBLIES ON UNIT
METAL
HEINTZ MFG. CO.
PHILADELPHIA, PA.
DIE DETAILS (NOSE)
30 MM T304 SK FSA 7757
FRANKFORD ARSENAL PHILA
DRAWN RIDGWAY 5-28-53
TRACED
CHECKED
APPROVED
D-147351
23704

12. STRESS RELIEF

The finished shell were placed in a Lindberg Electric Furnace, heated to a temperature of 740° F., held at this temperature for one (1) hour and air cooled.

The experimental work which was done to determine this temperature as well as the theoretical considerations involved will be discussed in more detail in the section on metallurgical data.

BODY, PROJECTILE, PRACTICE, 30MM

T304 and T241

MACHINING AND FINISHING OPERATIONS

Since only a very small quantity of these two shell (less than one hundred (100) each) were manufactured, the machining and allied operations, which were performed on turret lathes, will be described only in very general terms.

The machining operations necessary to finish a cold shell will be described in detail in conjunction with the description of manufacture of shell bodies T328 and T306E10 which follows. These shell we produced in quantities large enough to warrant using automatic machinery.

The first operation, which was done in a turret lathe, faced the open end to length, bored and chamfered the mouth diameter and tapped the 1-20 UNEF-2B thread.

With the piece chucked at the open end, the second operation formed and knurled the band seat.

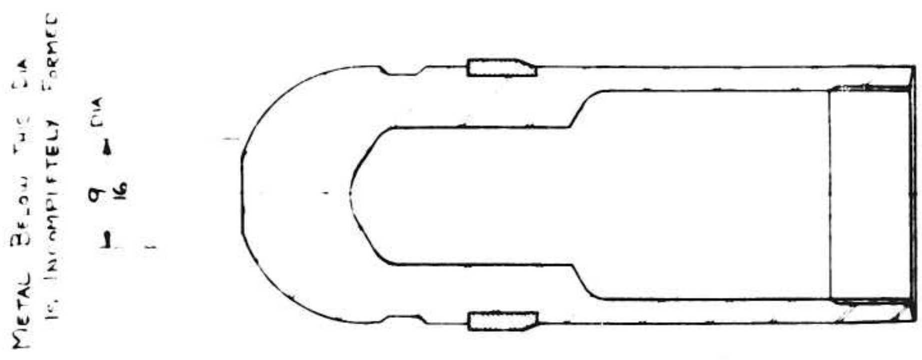
The rotating bands were applied using a small mechanical press. Each band was given two squeezes, at right angles to one another, to seat it in the groove and around the knurls.

The third and final lathe operation rough turned and

finish formed the rotating band and also formed the crimping groove.

The 9/16" diameter flat was machined on the base of the T241 shell body as a part of this operation and as shown by SK 10920 which is found on the following page.

The final operations necessary to complete the shell such as stencilling, bonderizing, painting, etc., were performed. A detailed description of such operations and the automatic equipment used will be discussed in conjunction with shell T328 and T306E10.



FILE NO.	CHANGE

ASSEMBLIES ON UNIT

CUST NO

METAL

NO REQ

A			F		
B			G		
C			H		
D			J		
E			K		

HEINTZ MFG. CO.
PHILADELPHIA, PA.

COLD FORMED VARIATION
D-7553344 PROJECTILE
PRACTICE, 30MM T-241
FRANKFORD ARSENAL, PHILA.

DRAWN RIDGWAY 10-22-53 | TRACED | CHECKED J L | APPROVED Sch 10-22-53 | APPROVED

E-

SKETCH NO
SK-10290

BODY, PROJECTILE, PRACTICE, 30MM

T304 and T241

INSPECTION GAGING AND PROCEDURES

The small number of shell produced prohibited either purchasing or building the quantity of gages that would be required for mass production.

The final inspection gages were the required standard gages of the snap, ring, plug and thread variety and were the property of the subcontractor.

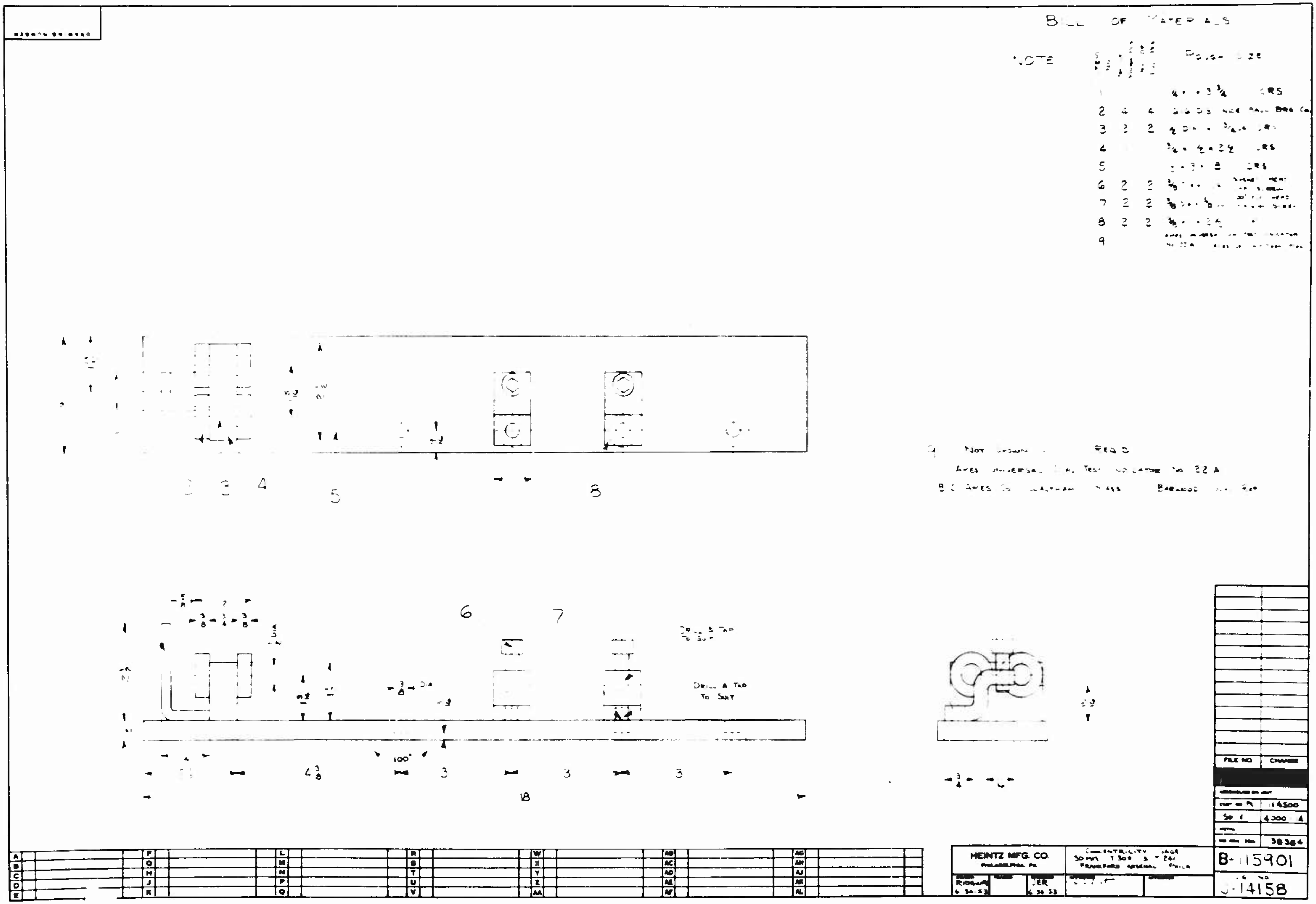
Gages designed and built by the Heintz Manufacturing Company for checking the cold forming operations are found on the pages immediately following.

The press set up gage, shown on Dwg #D-115904, was used to align the extrusion dies. The ram of the press was lowered until the punch just entered the die bushing. The gage was then placed on top of the bushing with the two pins in the die cavity. With the pin held firmly against the inside diameter of the die, the gage was rotated around the punch and the deflection of the indicator noted. The die was then shifted until the T.I.R. reading was .002" or less.

The gage shown on Dwg #B-115901 was used to check

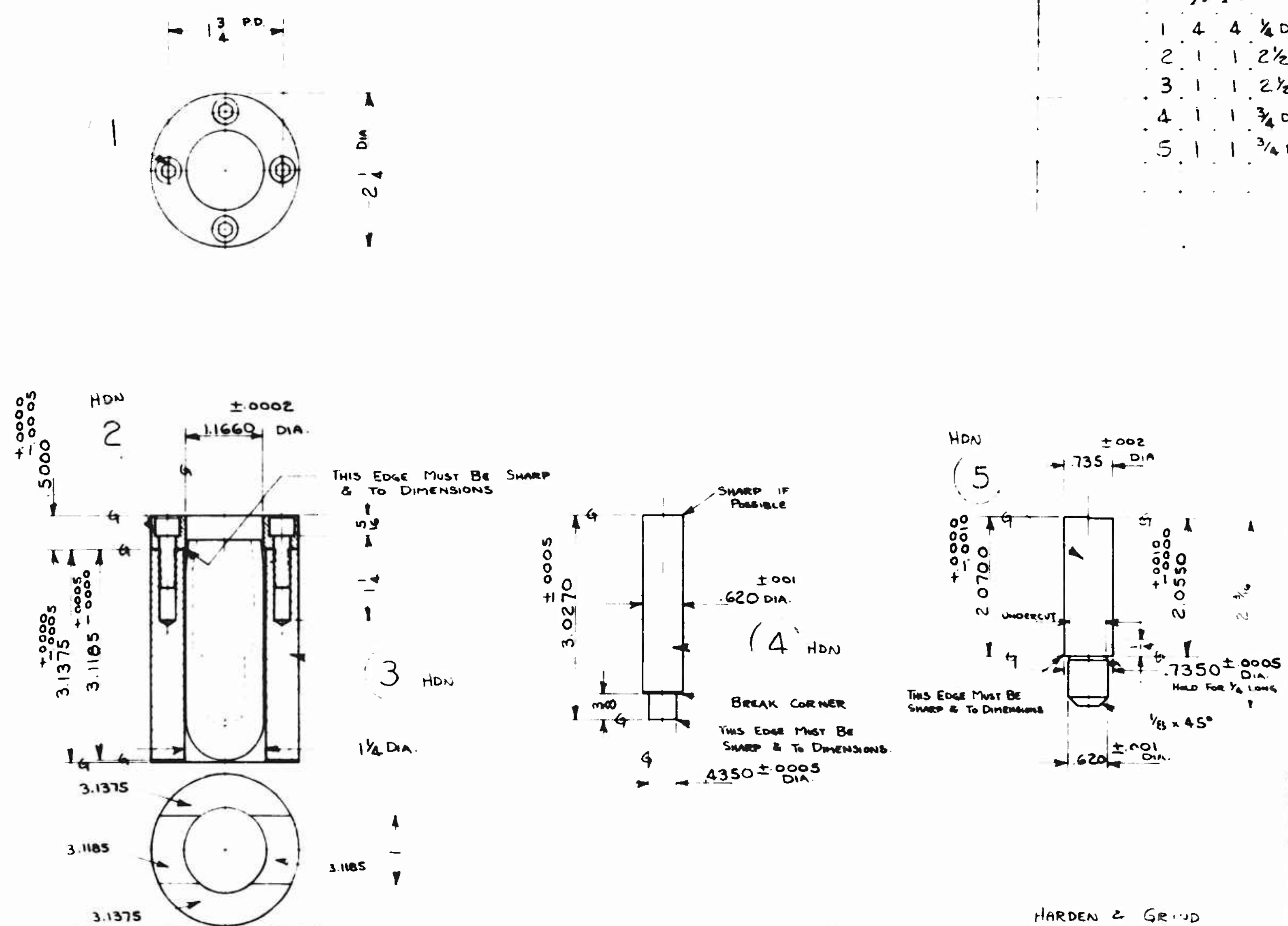
the concentricity or actually variation in wall thickness. The extruded pieces (both the process pieces and the final "blank") were placed on the rollers and moved against the stop. A long, slender, pointed rod, pivoted at its center point, was placed inside of the shell. The shell was rotated and the variation in wall thickness was measured by a dial indicator which measured the travel of the other end of the pivoted rod.

The gages shown on Dwg #D-115902 and #D-115903 were designed to measure the position of the inside bottom, and the shoulder of the shell with respect to the outside nose diameter.


BILL OF MATERIALS
NOTE
ROUGH SIZE
CRS
HEINTZ MFG. CO.
PHILADELPHIA, PA.
CONCENTRICITY GAGE
B-115901
14158
Drill & Tap To Suit
100°
18

Bill of Materials

Note	Item No.	No. of Rough Pcs	No. of Pcs	Rough Size
	1	4	4	1/4 Dia × 3/4 Lg Socket Hd Cap Screw
	2	1	1	2 1/2 Dia × 1 Lg • I T S
	3	1	1	2 1/2 Dia × 3 1/2 Lg • I T S
	4	1	1	3/4 Dia × 3 1/2 Lg • I T S
	5	1	1	3/4 Dia × 3 1/4 Lg • I T S



HARDEN & GRIND

FILE NO.	CHANGE

Assemblies on unit

CUST NO	114500
SO. E	4000-15
METAL	
... NO.	38385

HEINTZ MFG. CO.
PHILADELPHIA, PA.

LENGTH GAGES
30 MM. T 241
FRANKFORD ARSENAL PHILA

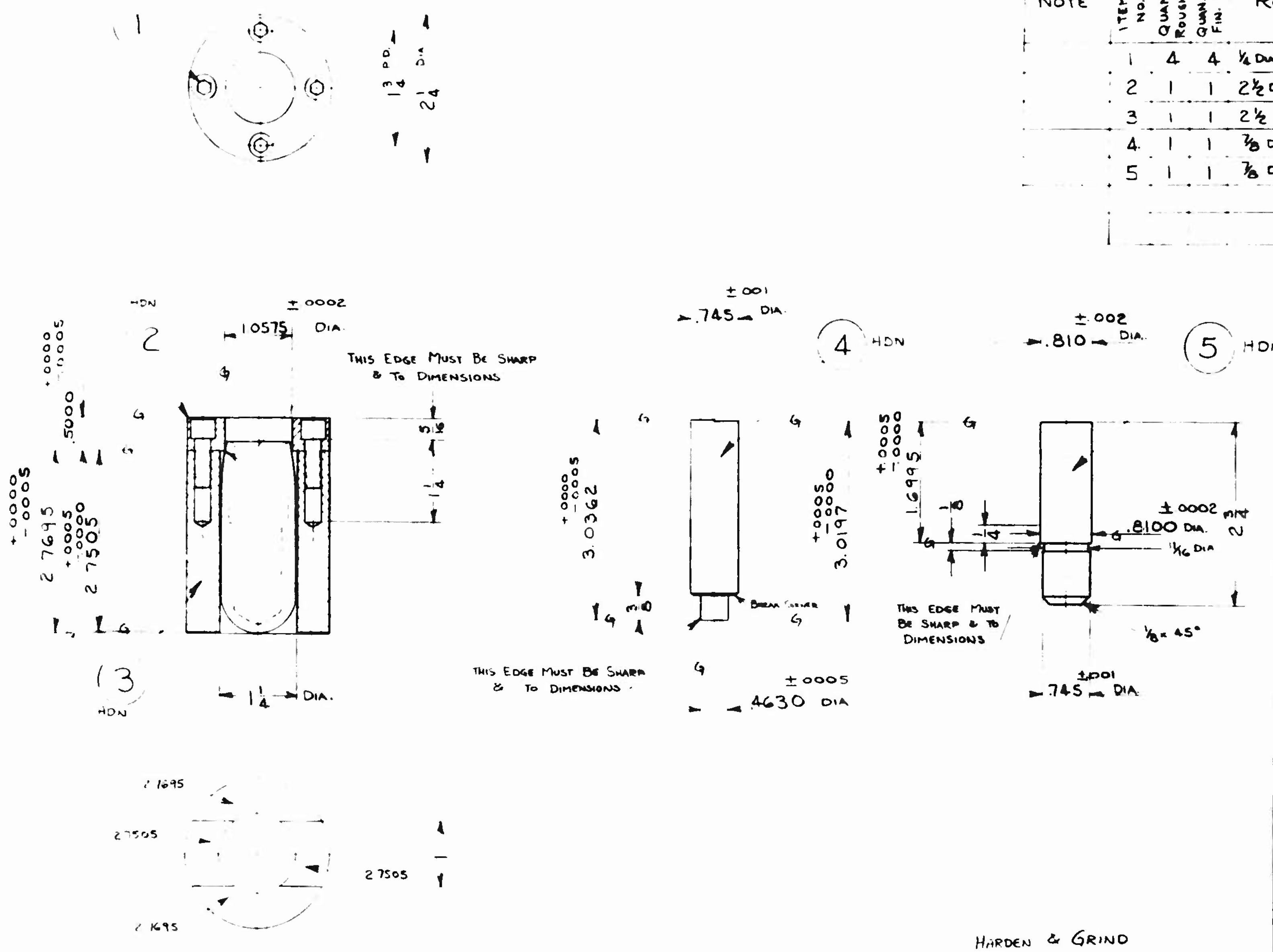
DRAWN	TRACED	CHECKED	APPROVED	APPROVED
RIDGWAY 6-30-53		JCC 6-30-53		

D-115902

JIG No. J 14159

BILL OF MATERIALS

NOTE	ITEM NO.	QUAN. OF ROUGH PCS.	QUAN. OF FIN. PCS.	ROUGH SIZE
	1	4	4	1/4 DIA. x 3/4 LG. SOCKET HEAD CAP SCREW
	2	1	1	2 1/2 DIA. x 1" LG. #1 T.S.
	3	1	1	2 1/2 DIA. x 3" LG. #1 T.S.
	4	1	1	7/8 DIA. x 3 1/2 LG. #1 T.S.
	5	1	1	7/8 DIA. x 3 LG. #1 T.S.



HARDEN & GRIND

FILE NO.	CHANGE
ASSEMBLIES ON UNIT	
CUST. NO	114501
SO. E	4000-16
METAL	
NO.	38386

HEINTZ MFG. CO. PHILADELPHIA, PA.

LENGTH GAGES 30 MM. T 304 FRANKFORD ARSENAL, PHILA.

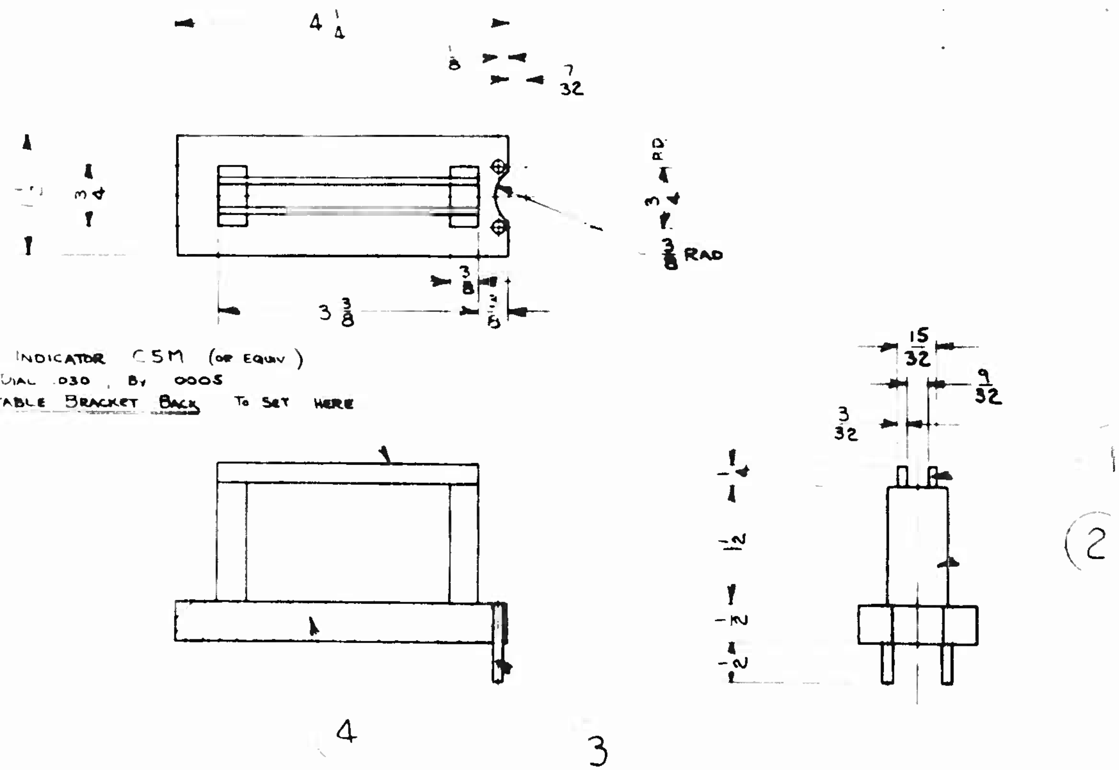
DRAWN RIDGWAY 7-2-53 | TRACED | CHECKED 7-2-53 | APPROVED

D-115903

JIG NO. J-14160

BILL OF MATERIALS

NOTE	ITEM NO	QUAN ROUGH	QUAN FIN	ROUGH SIZES
	1	2	2	3/32 × 1/4 × 3 1/2 CRS
	2	2	2	3/8 × 3/4 × 1 1/2 CRS
	3	2	2	1/8 DIA × 1 LG DOWEL PINS
	4	1	1	1/2 × 1 1/2 × 4 3/8 CRS
	5	1	1	FEDERAL DIAL INDICATOR CSM WITH ADJUSTABLE BRACKET BACK



▸ FEDERAL DIAL INDICATOR CSM (OR EQUIV)
RANGE .075 DIAL .030, BY .0005
WITH ADJUSTABLE BRACKET BACK TO SET HERE

FILE NO.	CHANGE
ASSEMBLED ON UNIT	
CUST NO	2503
SO E	4090
METAL	
MFG ORD No	38387

HEINTZ MFG. CO.
PHILADELPHIA PA.

PRESS SET-UP JIG
30MM - T304 & T241
FRANKFORD ARSENAL PHILA.

D-115904

JIG No J-14161

7-6-54

BODY, PROJECTILE, PRACTICE, 30MM

T304 and T241

METALLURGICAL DATA AND DISCUSSION

The stated requirements for these shell included the following mechanical properties:

Yield strength	90,000 psi
Elongation	10%

Previous experience, and the thinking as outlined in the Engineering Considerations section of this report, indicated that a carbon steel of type AISI 1021 was needed to meet these requirements. This steel was purchased from Bethlehem Steel Company and had the following ladle analysis:

Heat No 49N294

C	-	.19
Mn	-	.95
P	-	.018
S	-	.034
Si	-	.03

Further examination of this heat of steel established the following facts:

1. Structure: Typical pearlite in a ferrite structure with the ferritic grain size 6-8

2. Hardness: 75-80 R_B

The shearing operation previously described severely

worked the faces of the slug requiring an anneal to remove this effect so that the pieces might be further cold worked. Several experiments were performed to establish the best annealing cycle. A cycle which consisted of holding the slugs for two (2) hours at 1250° F. was determined to be the most satisfactory in that it softened the surface of the slugs without altering the structure of the steel. Sketches showing the hardness pattern of the billet before and after annealing are found on the pages immediately following the text of this section.

Four factors determine the final mechanical properties of a cold formed shell--(1) the initial mechanical properties of the steel, (2) the type of steel selected, (3) the extent to which the structure of the material is strained, and (4) the choice of the stress relief temperature.

From experience, some theoretical data, and considerable empirical data it is possible to determine, at least approximately, the mechanical properties that will result from various amounts of cold working a given material.

The tensile test curve of a severely cold worked steel specimen which has not been stress relieved shows a very low propor-

tional limit.

The yield strength determined from testing a specimen which has been stress relieved at any temperature other than the optimum will be low, and the full advantage of obtaining this increased strength through strain hardening will not have been realized.

The results of several experiments performed to determine the optimum stress relief temperature are reported below.

Specimen	Stress Relief	Tensile Str.	Yield Str. (.1% Off)	Elong. in 1/2"
T241 SHELL				
1	None	89,750 psi	74,750 psi	12.5%
1A	None	90,000 "	81,000 "	12.5%
2	740° F 30 min.	95,000 "	84,300 "	18.75%
2A	740° F 30 min.	93,500 "	82,500 "	12.5%
3	700° F 45 min.	98,250 "	Bad Test	9.38%
3A	700° F 45 min.	97,000 "	82,700 "	12.5%
T304 SHELL				
4	None	103,000 psi	85,250 psi	12.5%
4A	None	101,500 "	91,000 "	*
5	740° F 30 min.	105,000 "	93,250 "	12.5%
5A	740° F 30 min.	106,100 "	94,500 "	15.63%
6	700° F 45 min.	Not Tested - Mechanical Difficulties		
6A	700° F 45 min.	106,500 "	100,600 "	9.38%

*Specimen broke through gage mark.

NOTE: Two specimen tested from each shell.

BODY, PROJECTILE, PRACTICE, 30MM

T304 and T241

METALLURGICAL DATA AND DISCUSSION (Cont.)

These results were disappointing and inconsistent with previous experience. The Metallurgical Laboratory of Frankford Arsenal in Philadelphia kindly agreed to further check specimen from these same shell. These results are listed as follows:

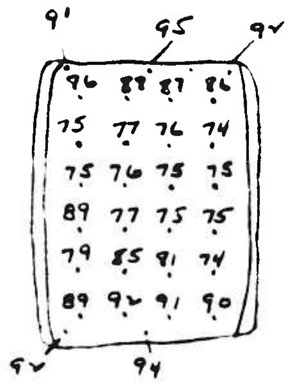
Specimen	Stress Relief	Tensile Str.	Yield Str. (.1% Off)	Elong. in 1/2"
T241 SHELL				
1A	None	124,100 psi	110,800 psi	10.0%
1B	None	122,900 "	117,700 "	10.0%
2A	700° F 45 min.	118,300 "	116,500 "	10.4%
2B	700° F 45 min.	119,600 "	114,600 "	9.6%
3A	740° F 30 min.	108,700 "	109,100 "	10.8%
3B	740° F 30 min.	117,000 "	112,400 "	10.0%
T304 SHELL				
4A	None	101,700 psi	88,300 psi	10.4%
4B	None	103,600 "	99,300 "	10.0%
5A	700° F 45 min.	107,600 "	97,100 "	10.8%
5B	700° F 45 min.	104,200 "	97,200 "	10.4%
6A	740° F 30 min.	107,000 "	99,700 "	11.2%
6B	740° F 30 min.	106,700 "	98,200 "	11.2%

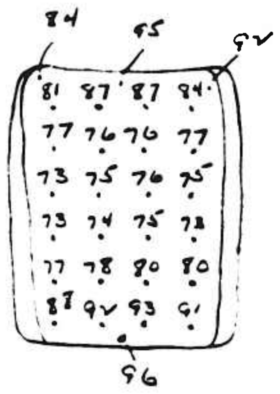
A comparison of these data indicate an extreme variation in results. The data obtained by Heintz indicated that the yield strength was slightly lower than the required 90,000 psi while the Arsenal's results show yield strength considerably in excess of that required. Metallurgists of both parties were unable to explain these

discrepancies which probably reflect the practical mechanical difficulties attendant upon the testing of such small specimen.

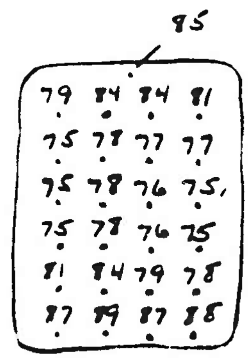
BY 7Hm DATE 5/3/54 SUBJECT 30 MM Shell
CHKD. BY DATE T241 & T304 Shell
SHEET NO. OF
JOB NO.

HARDNESS SURVEYS OF SHEARED BILLETS
HARDNESS READINGS RB SCALE



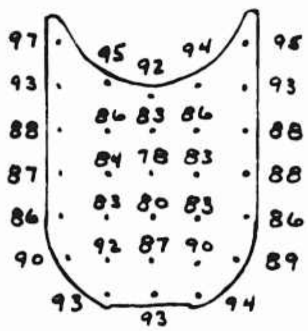


HARDNESS SURVEY OF SHEARED BILLET ANNEALED
AT 1350 FOR 2 HOURS
HARDNESS READINGS RB SCALE

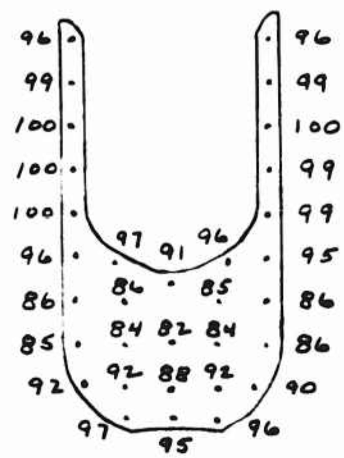


BY HM DATE 5/3/54 SUBJECT 30 MM SHELL SHEET NO. ...... OF ......
CHKD. BY ...... DATE ...... T 304 SHELL JOB NO. ......
HARDNESS PATTERN

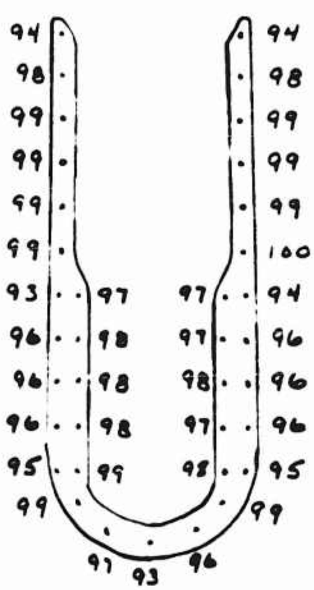
HARDNESS READINGS RB SCALE



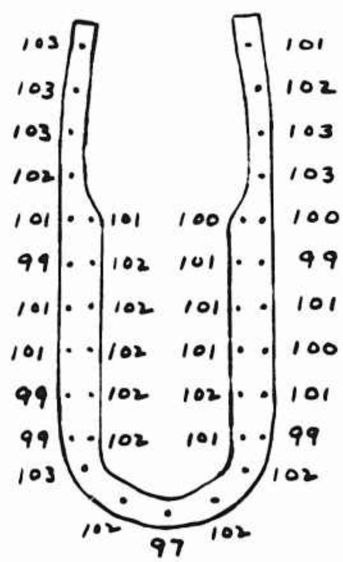
SIZED PIECE



1ST BACKWARD EXTRUSION



2ND BACKWARD EXTRUSION



NOSED PIECE

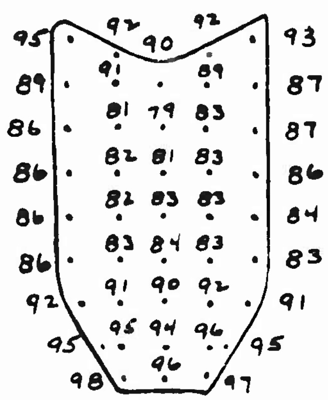
SLUG ANNEALED BEFORE SIZING OPERATION. NO OTHER ANNEALS.

BY HLM DATE 5/3/54 SUBJECT 30 MM SHELL SHEET NO. .... OF ......

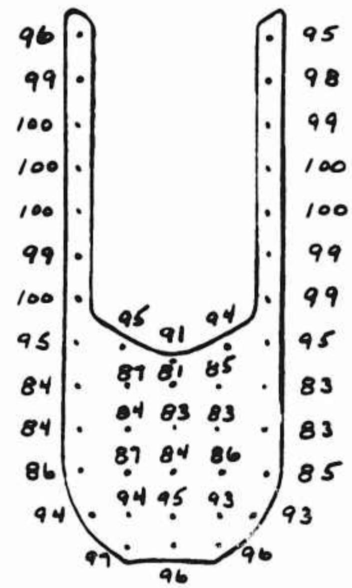
CHKD. BY .... DATE .... T 241 SHELL JOB NO. ....

HARDNESS PATTERNS

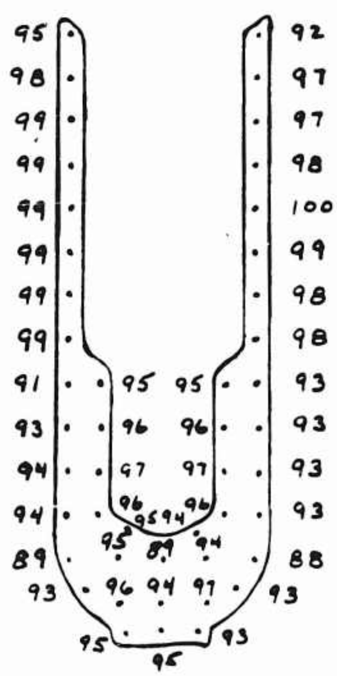
HARDNESS READINGS R_B SCALE



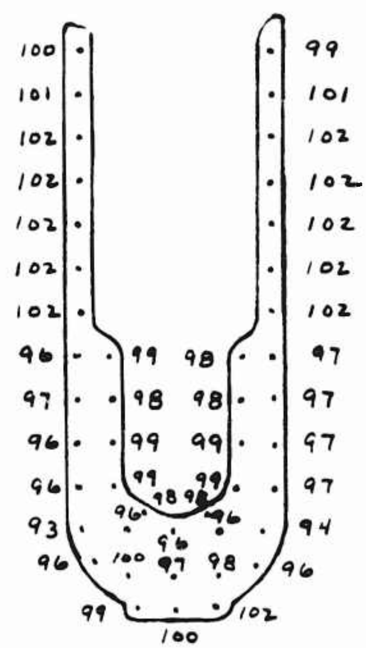
SIZED PIECE



1ST BACKWARD EXTRUSION



2ND BACKWARD EXTRUSION

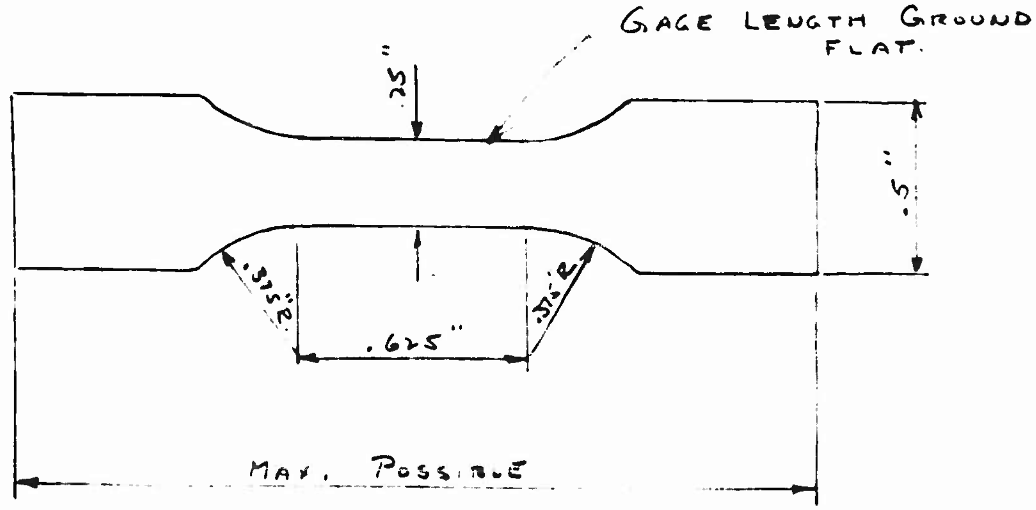


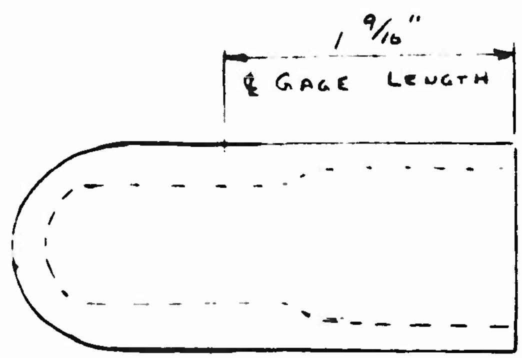
NOSED PIECE

SLUG ANNEALED BEFORE SIZING OPERATION. NO OTHER ANNEALS.

BY HHM DATE 8/3/51 SUBJECT 30 MM SHELL
CHKD. BY DATE T241 & T304 SHELL
TENSILE TEST SPECIMENS

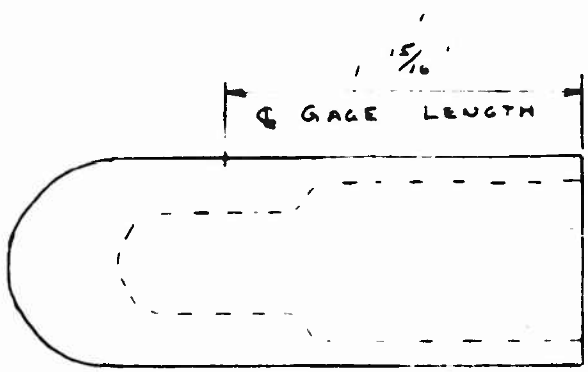
SHEET NO. OF
JOB NO.





SPECIMEN LOCATION

T 304 SHELL



SPECIMEN LOCATION

T241 SHELL

BODY, SHELL, HEI, 30MM, T306E10

BODY, SHELL, HEI, 30MM, T306E10

ENGINEERING CONSIDERATIONS

The shape of this shell with the heavy wall thickness in the open end necessitated using operations such as forward extrusion or draws which would thin the wall in the lower end of the shell leaving the heavy open end undisturbed. Therefore, it was possible to depict the operation designated as first draw on a sequence of operations Dwg #E-120471 which follows immediately after the text on Engineering Considerations.

This piece designated as first draw had to meet the mechanical property requirements of 90, 000 psi yield minimum and 10% elongation, since at this stage all of the heavy operations would have been performed.

These mechanical properties were derived from the cold work done following the last process anneal. A process anneal had to follow the backward extrusion operation, since the metal was so severely worked that little ductility remained. Therefore, the shape of the piece which must have the proper yield strength was known, as well as the required reduction in area necessary to produce it. With this knowledge it was then possible to determine the shape of the theoretical backward extruded piece. This theoretical shape was

then analyzed to determine what reduction in area was required to produce it and if the reduction was not excessive this theoretical shape became the actual backward extruded shape.

The billet size could then be determined in that the outside diameter of the backward extruded piece required that the outside diameter of the billet be the nearest commercially available bar size. The height of the billet was calculated using this diameter and the knowledge of the required volume of metal in the finished shell.

The operations between backward extrusion and first draw had then to be considered. The shape and the required reduction almost dictated that a forward extrusion, with its great capacity for heavy reductions, be used. The first draw could then be a relatively light operation which could be used advantageously to form the outside and inside diameters to their required sizes.

If the first draw piece were nosed to form the finished shape of the shell, the required force would stress the thin walled section to a value in excess of its yield point and this thin wall would upset. The method used to solve this problem was to employ two operations so designed that in neither was the load required sufficient to yield the thin wall. Such an operation is shown on Dwg #E-120471

and designated as second draw.

Economic considerations demanded that the billet be sheared rather than sawed from the bar stock. Therefore, an anneal was required to remove the effects of the shearing and another press operation had to be employed to shape this distorted sheared slug and form the 1.408" outside diameter.

Before the sheared billet could be sized it was necessary to remove the mill scale from the outside diameter and any burrs caused by the shearing and, of course, to surface treat the piece.

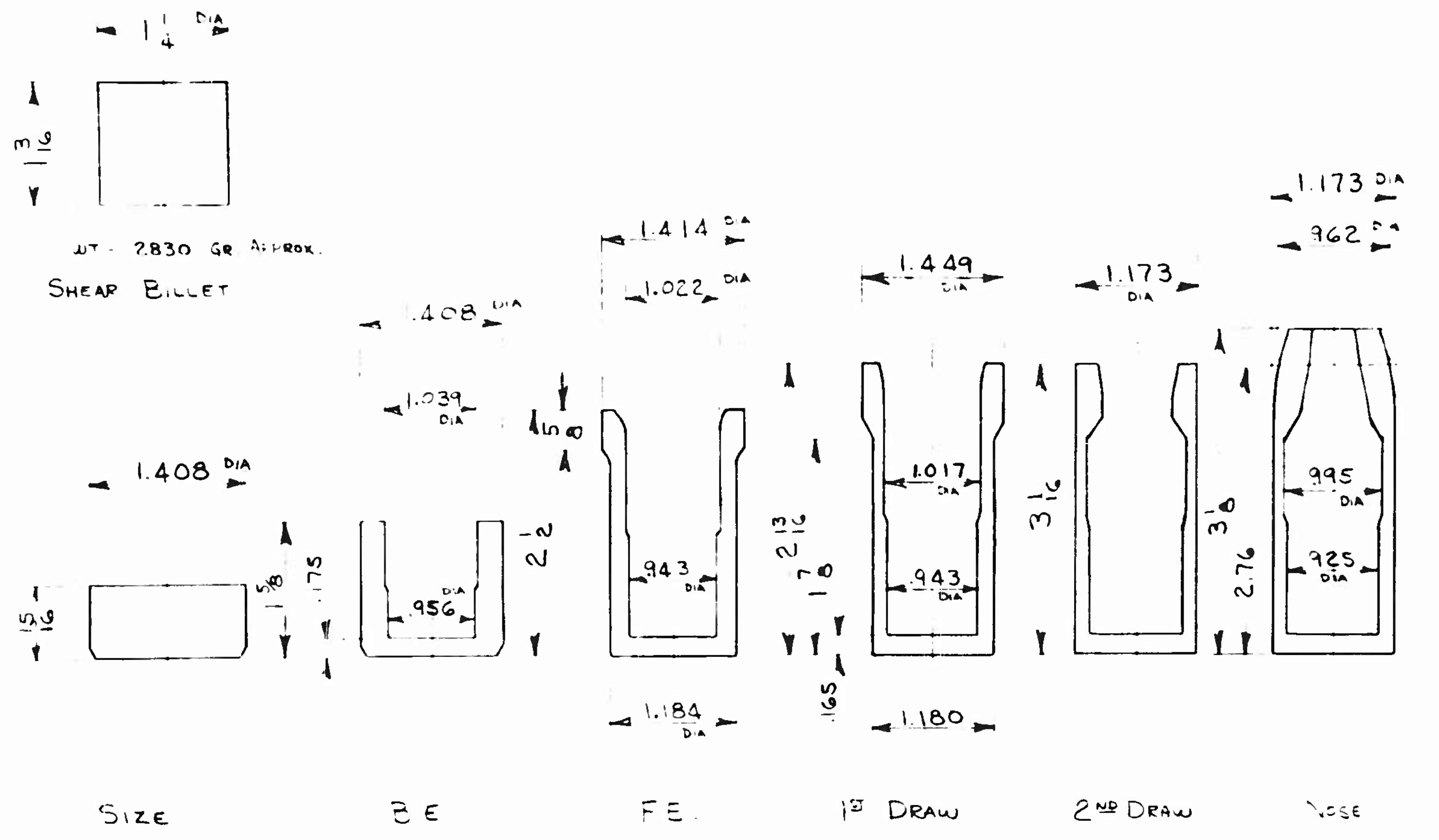
Thus the complete theoretical or basic sequence of cold forming operations was:

1. Shear Billet
2. Tumble
3. Anneal
4. Wheelabrate
5. Surface Treat
6. Size
7. Surface Treat
8. Backward Extrude
9. Anneal
10. Surface Treat
11. Forward Extrude
12. First Draw
13. Second Draw
14. Nose
15. Stress Relieve

ENGINEERING CONSIDERATIONS (Cont.)

With this information the tools necessary to form the required shape could be designed and built, and all gages, jigs, and auxiliary equipment for surface treating could be made.

These operations will now be discussed in detail with regard for the practical tooling, metallurgical, chemical and manufacturing problems.



SIZES ARE APPROX. OR DESIGN SIZES

FILE NO.	CHANGE

ASSEMBLIES ON UNIT

CUST. NO

METAL

NO. REQ

HEINTZ MFG. CO.
PHILADELPHIA PA.

SEQUENCE FOR PRESS WKG ON BODY FD 18083A SHELL HE 30MM T306 E10 FRANKFORD ARSENAL

E-120471

DRAWN	TRACED	CHECKED	APPROVED	APPROVED
JER 8-16-54		J.R. BENSON 9-17-54	[illegible]	

BODY, SHELL, HEI, 30MM, T306E10

COLD FORMING OPERATIONS

1. SHEAR BILLET

The tools necessary to shear the 1-1/4" bar stock are shown on Dwg #B-114782 (p. 20).

The bar stock was manually fed into the die during the up stroke of the press, and the billets fell out below the die.

This operation was identical in detail to that described for the T241 and T304 bodies with the exception of adjusting the stop to make the billet of the required weight of 2, 800 grains for this particular shell.

The die was run on a 100 ton Verson mechanical press. The actual tonnage required was 43 tons.

2. TUMBLE BILLETS

The purpose of this procedure was to remove any sharp edges and burrs from the faces of the sheared billet. A distorted slug, as produced by shearing, did not lend itself to automatic chamfering of the billet edges, and a manual grinding operation to remove burrs was economically prohibitive.

Tumbling was an economical operation in that only a part-time operator was required to load and unload the tumbler, of one thousand (1, 000) pieces in a cycle time of forty-five (45) minutes.

3. ANNEAL BILLETS

If the billet were to be further cold worked it was imperative that the original ductility be restored to the severely worked sheared surface. An anneal was therefore required. This thermal treatment also minimized the piece-to-piece and bar-to-bar differences in hardness, and thereby enhanced the repetitive accuracy of the cold forming operations.

The billets were heated to a temperature of 1275° F. in a Lindberg Electric Furnace, soaked at this temperature for one and one-half (1-1/2) hours and air cooled.

Reference should be made to the section on Metallurgical Data which shows the effect of this anneal on the hardness of the sheared billet.

4. SHOTBLAST

It was virtually impossible to have an automatic surface treating cycle that was compatible with the tenacious scale found on the surface of hot rolled bars, and the smooth, clean surface of pieces that had been previously extruded. The most economical method of removing this scaled surface was mechanical blasting.

These pieces were "wheelabrated" on a tumble blast machine manufactured by American Wheelabrator Corporation, using soft "nail whiskers" as shot. It was very important that soft shot of some kind be used as hard shot tended to imbed itself in the relatively soft billet and would score the die used to form it.

5. SURFACE TREAT BILLETS

This surface treatment, or "Foscoating", operation was done on the Heintz experimental, manual Foscoating line. The pieces were placed in stainless steel trays by an operator and then were carried in baskets through the chemical cycle which follows:

1. Alkaline clean
2. Cold water rinse
3. Sulphuric acid pickle
4. Cold, overflowing water rinse
5. Hot, overflowing water rinse
6. Foscoat
7. Cold, overflowing water rinse
8. Hot, overflowing water rinse
9. Lubrication

Chemicals were supplied by Pennsylvania Salt Manufacturing Company of Philadelphia.

A complete description of the chemical constituents and process controls is contained in the appendix section entitled "Chemical Data".

6. SIZE BILLET

The tools necessary to perform this operation are shown on Dwg #D-119843-1 which immediately follows the text describing this operation.

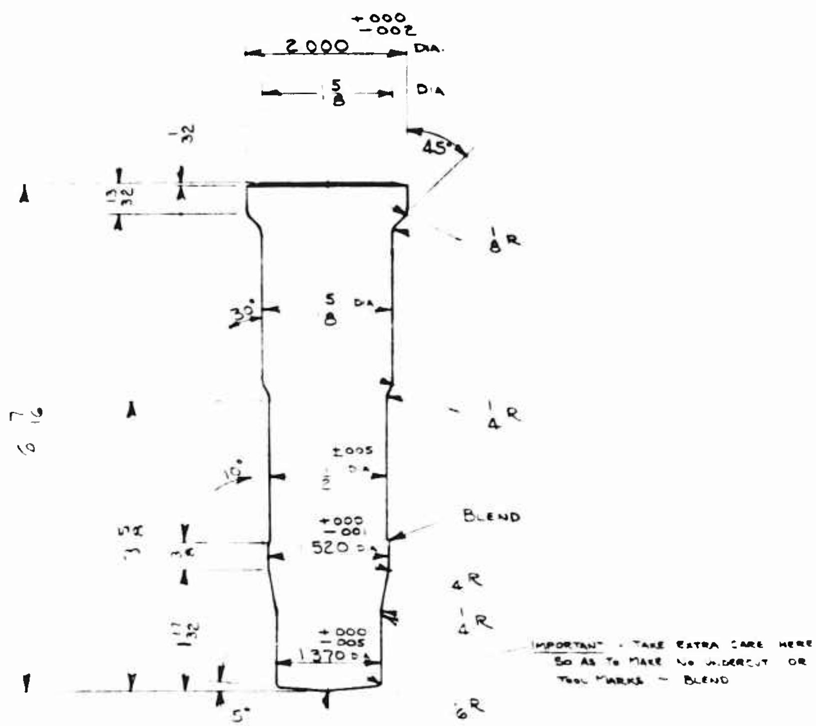
Since all billets were sheared from 1-1/4" bar stock, this sizing operation, in addition to its usual function of shaping the distorted slug, also expanded its diameter to the required 1-1/2".

As previously described, the punch (Item #7), the bushing (Item #8), and the knockout pin (Item #18) were the actual forming elements of this die. These parts were so designed as to be interchangeable with the remainder of the assembly. This assembly was then suitable not only for this operation but for all subsequent extrusions.

The only difficulty experienced with the die other than ths usual alignment problems was the exceedingly critical nature of the press shut height adjustment. This was nearly a confined die and too low a setting of the shut height would have resulted in complete confinement and excessive tool stresses.

SIZE BILLET (Cont.)

The operation was performed on a Verson press rated at 100 tons 6" up from bottom dead center. The actual tonnage required for this operation was 233 tons.



ROUND

HIGHLY POLISH BEFORE HARDENING & AFTER
MUST BE FREE OF NICKS, SCRATCHES & TOOL MARKS

PUNCH

MATERIAL - STAMINAL OHTS
HARDEN - Rc 59-60

NOTE:-
USE WITH DIE # 24954
CHANGE PUNCH ONLY

FILE NO.	CHANGE

ASSEMBLED ON UNIT	
CUST. NO.	108102
So. E	4017-S
METAL	
ORD. NO.	46651

HEINTZ MFG. CO.
PHILADELPHIA, PA.

DIE PART DETAILS (SIZE)
30 MM, T306E10 - FD 18083
FRANKFORD ARSENAL

JER. 9-20-54

10-4-54

T. [illegible] 10-4-54

D-119843-1

DIE NO. D-24953

7. SURFACE TREAT SIZED PIECE

This operation was identical with Operation #5.

It was always necessary to coat prior to a backward extrusion operation. Backward extrusion caused the coating to stretch, at least locally, as much as 800%, and anything less than a proper coating would not withstand such severe treatment.

8. <u>BACKWARD EXTRUDE</u>

The tools required to backward extrude this shell are shown on Dwg #D-119844 which immediately follows the text of this section.

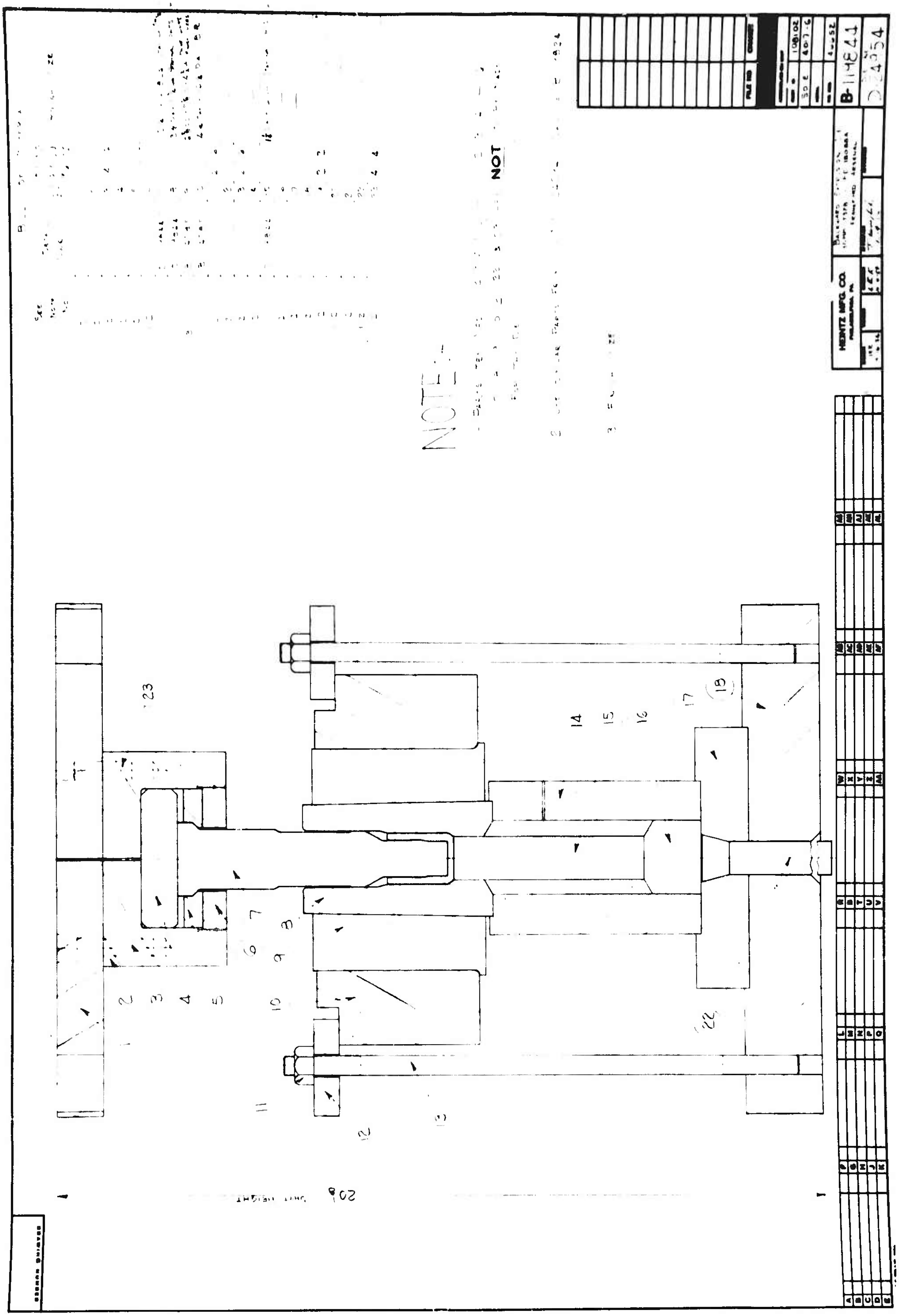
As with the previously described dies, the punch, bushing and knockout pin were the actual forming elements which were designed as replaceable parts of the complete die assembly.

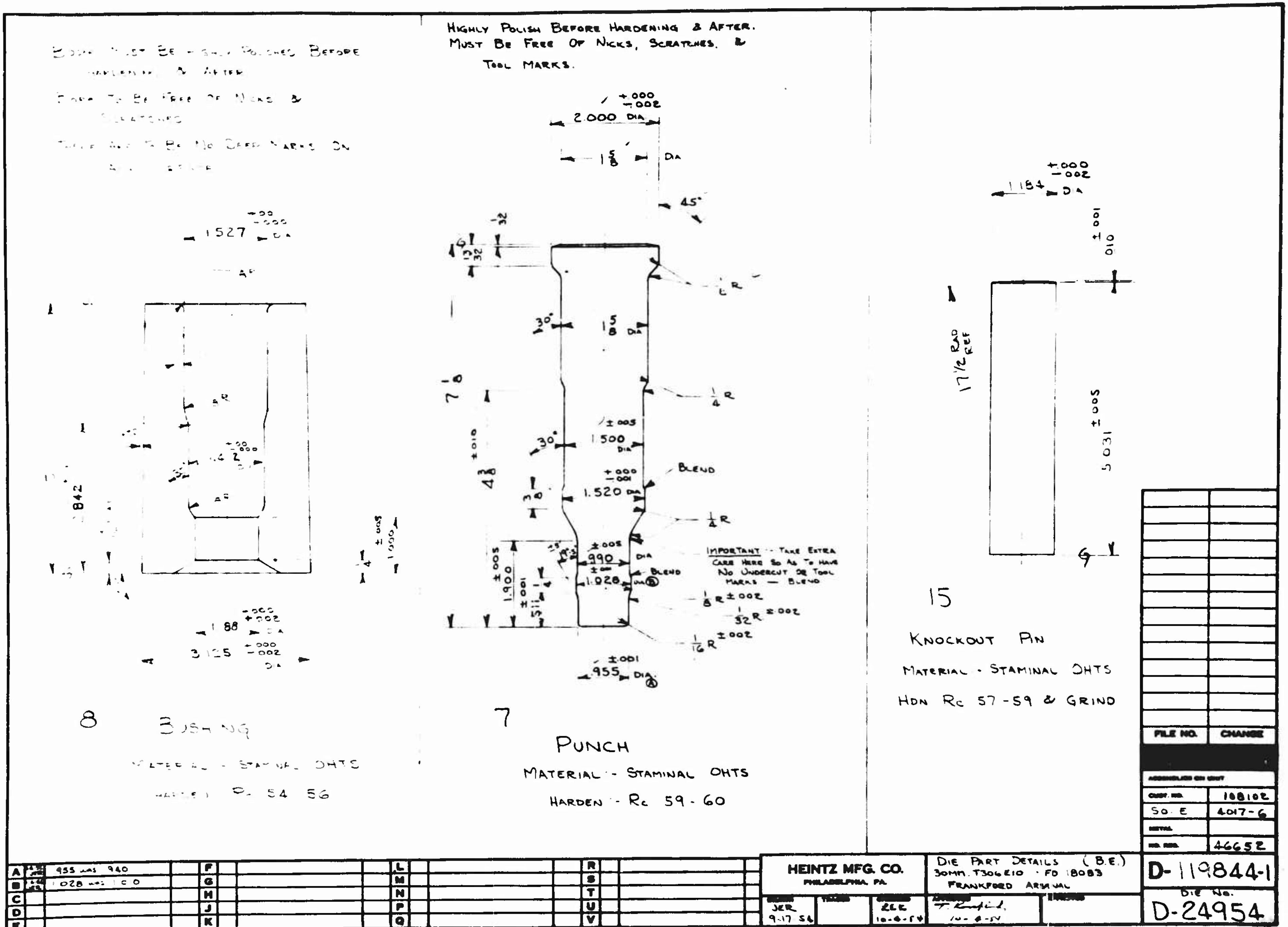
This die, like all extrusion dies, had to be very carefully aligned because this operation, in addition to drastically forming the metal, also determined the concentricity of the piece which had to be held within .008" T.I.R.

The billet was placed in the die and the punch forced it down to the knockout pin and then stressed the metal to the point where it flowed upward through the annular orifice between punch and bushing. The press shut height was set to give the required bottom thickness of .180 to .185". This dimension, as well as eccentricity, was carefully checked when setting this die and at frequent intervals when the die was running.

BACKWARD EXTRUDE (Cont.)

This operation was performed on a 100 ton Verson single point suspension press. The required force to form this piece was 125 tons.


NOTE
NOT
HEINTZ MFG. CO.
PHILADELPHIA, PA.
B-114E41



HIGHLY POLISH BEFORE HARDENING & AFTER.
MUST BE FREE OF NICKS, SCRATCHES, & TOOL MARKS.
2.000 DIA +.000 −.002
1 5/8 DIA
45°
30°
1 5/8 DIA
1/4 R
1.500 DIA ±.005
BLEND
1.520 DIA +.000 −.001
1/4 R
.990 ±.005 DIA
1.028 ±.001 DIA
BLEND
IMPORTANT - TAKE EXTRA CARE HERE SO AS TO HAVE NO UNDERCUT OR TOOL MARKS — BLEND
1/8 R ±.002
1/32 R ±.002
1/16 R ±.002
.955 ±.001 DIA
1.900 ±.005
4 3/8 ±.010
7 1/8
7
PUNCH
MATERIAL - STAMINAL OHTS
HARDEN - Rc 59 - 60
1.527 DIA
1.88 DIA +.000 +.002
3.125 DIA +.000 −.002
.842
1.000 ±.005
8
BUSHING
MATERIAL - STAMINAL OHTS
1.154 DIA +.000 −.002
.100 ±.010
5.031 ±.005
17 1/2 RAD REF
15
KNOCKOUT PIN
MATERIAL - STAMINAL OHTS
HDN Rc 57-59 & GRIND
FILE NO.
CHANGE
CUST. NO. 108102
S.O. E 4017-6
NO. REQ. 46652
HEINTZ MFG. CO.
PHILADELPHIA, PA.
DIE PART DETAILS (B.E.)
30MM. T306E10 · FD 18083
FRANKFORD ARSENAL
D-119844-1
DIE NO.
D-24954
JER 9-17-56
ZEE 10-8-56
A .955 WAS .940
B 1.028 WAS 1.00

9. <u>ANNEAL</u>

The very severely cold worked backward extruded piece was annealed to restore sufficient ductility to allow further cold forming.

A sub-critical anneal which restored the original softness and ductility without changing the structure of the metal was used.

The pieces were heated to a temperature of 1150° F. in a Lindberg Electric Furnace, soaked at this temperature for one and one-half (1-1/2) hours, and air cooled.

The results of this anneal may best be understood by referring to the sketches showing the hardness of the material before and after this thermal treatment. These sketches are found in the section on Metallurgical Data.

10. <u>SURFACE TREAT</u>

This operation was identical to the surface treating previously described with the exception that some provision had to be made to oscillate the pieces to expel the air from the cavity. This was accomplished by placing pieces in a basket that was rotated about 30^{o} on either side of the horizontal position.

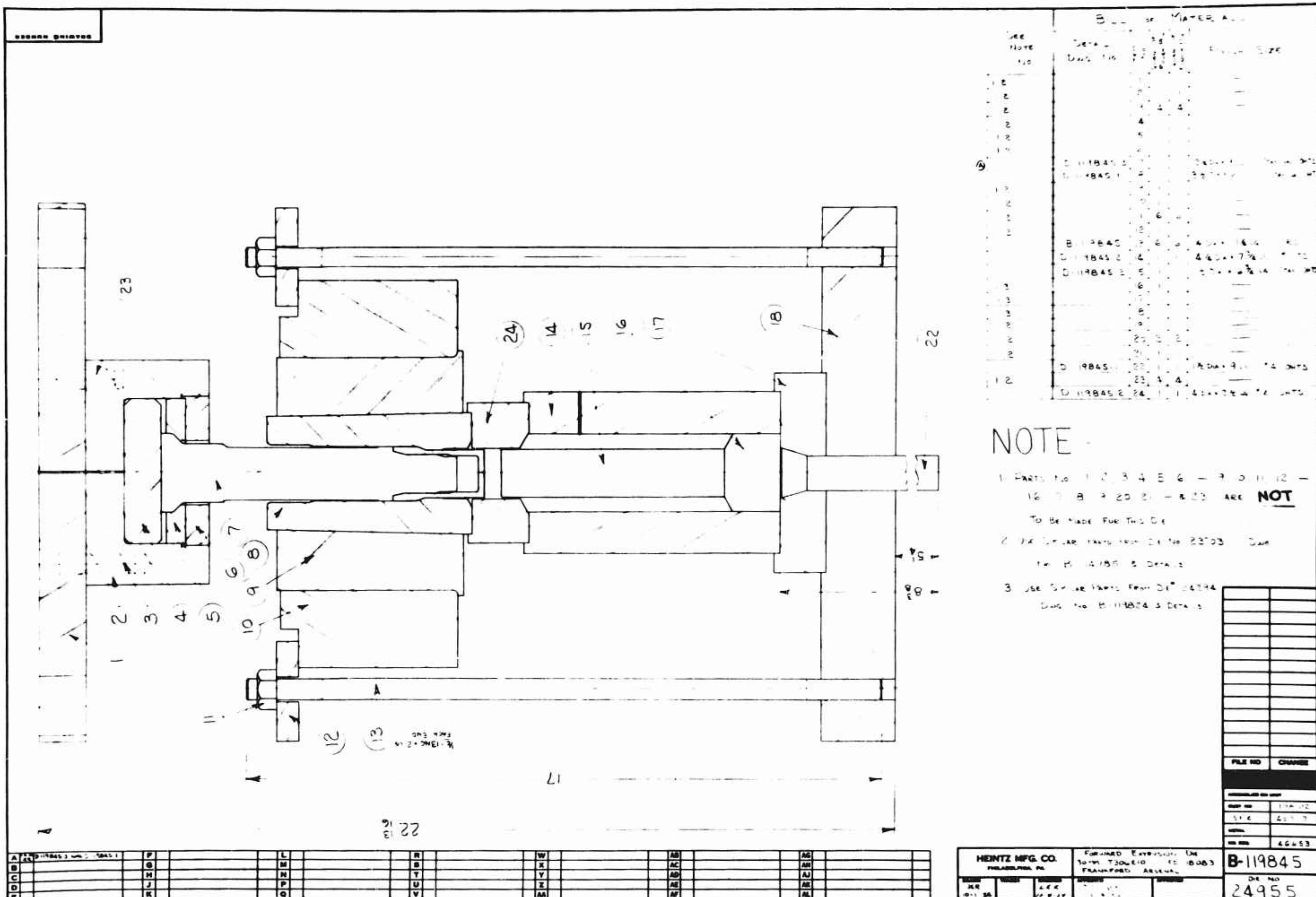
11. FORWARD EXTRUDE

Basically, forward extrusion was accomplished by placing a backward extruded "cup" into a die and using a punch which pressed on the top of the piece.

This operation was performed in the above described manner and the depth to which the punch entered the die determined the length of the thick walled section at the open end of the shell. This distance from the bottom of the shell to the extrusion shoulder had to be 1-1/2" plus 1/16 minus 0. The pieces were checked to assure the concentricity of .008 maximum was not increased by this operation.

The tooling required to make this piece is shown on Dwg #B-119845.

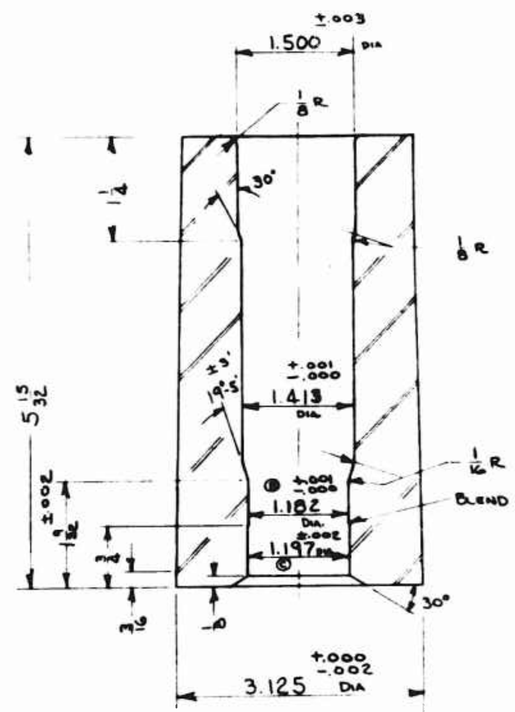
This die was run on a 100 ton mechanical Verson press although the required force was only 60 tons.


BILL OF MATERIAL
NOTE
ARE NOT
To Be Made For This Die
HEINTZ MFG. CO.
PHILADELPHIA, PA.
FORWARD EXTRUSION DIE
FRANKFORD ARSENAL
FILE NO
CHANGE
B-119845
DIE NO
24955
17
22 13/16

BORE MUST BE HIGHLY POLISHED BEFORE HARDENING & AFTER.

BORE TO BE FREE OF NICKS & SCRATCHES.

THERE ARE TO BE NO DEEP MARKS ON ANY SURFACE.

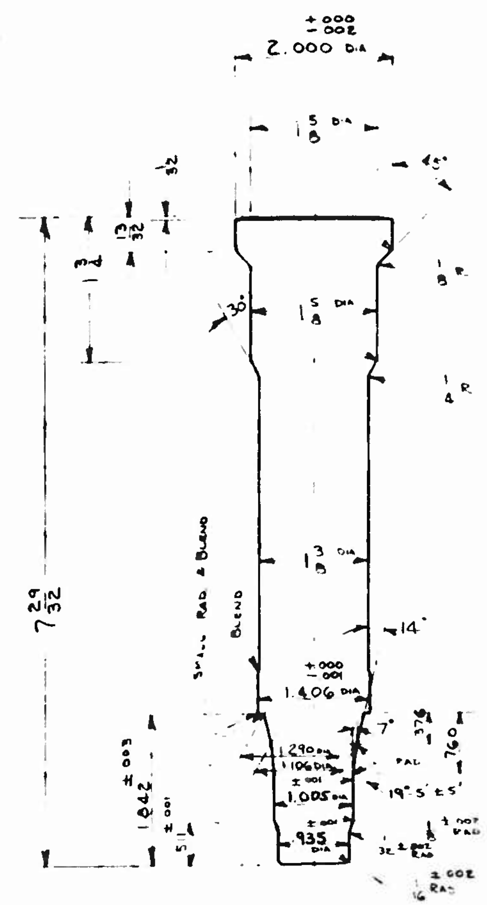


(8)

BUSHING

MATERIAL :- STAMINAL OHTS

HARDEN :- Rc 54 - 56

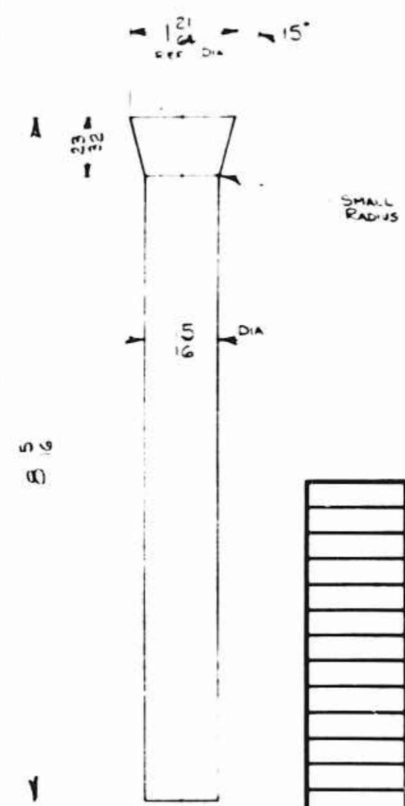


HIGHLY POLISH BEFORE HARDENING & AFTER
MUST BE FREE OF NICKS, SCRATCHES,
TOOL MARKS & UNDERCUTS

(7) Ⓐ PUNCH

MATERIAL :- STAMINAL OHTS

HARDEN :- Rc 59 - 60



22

HANGING KNOCKOUT

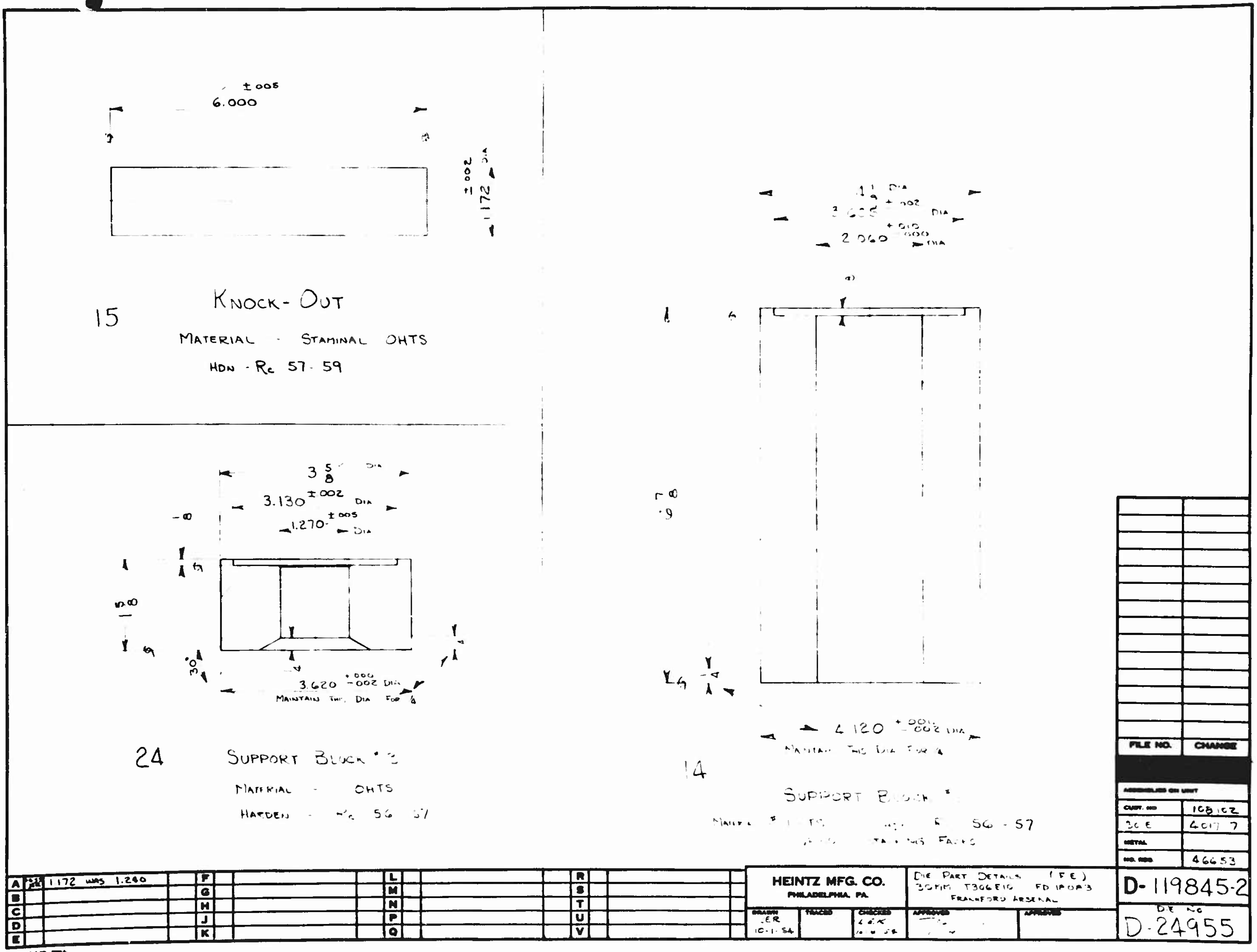
MATERIAL :- #4 OHTS

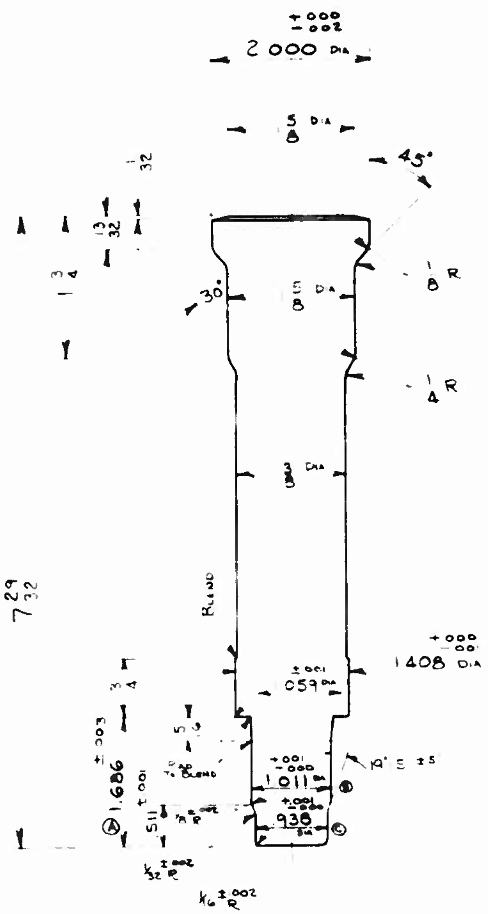
HARDEN :- TOUGHEN

A	PUNCH WORD		
B	1.182 WAS 1.230		
C	1.197 WAS 1.265		
D			
E			

FILE NO.	CHANGE
ASSEMBLED ON UNIT	
CUST. NO.	108102
SO. E.	4017-7
METAL	
NO. REQ.	46653

HEINTZ MFG. CO. PHILADELPHIA PA.	DIE PART DETAILS (FE) 30MM. T306 E10 - FD 18083 FRANKFORD ARSENAL	D-119845-1
DRAWN JER 10-1-54 / TRACED / CHECKED L.G.R. 10-8-54	APPROVED / APPROVED	DIE NO. D-24955


6.000 ±.005
1.172 ±.002 DIA
15
KNOCK-OUT
MATERIAL - STAMINAL OHTS
HDN - Rc 57-59
3 5/8 DIA
3.130 ±.002 DIA
1.270 ±.005 DIA
3.620 +.000 -.002 DIA
MAINTAIN THIS DIA FOR
24
SUPPORT BLOCK
MATERIAL - OHTS
HARDEN
2.060 +.010 -.000 DIA
4.120 DIA
14
SUPPORT BLOCK
56 - 57
1.172 WAS 1.240
FILE NO.
CHANGE
ASSEMBLIES ON UNIT
CUST. NO
1C8 ICZ
4017 7
METAL
46653
HEINTZ MFG. CO.
PHILADELPHIA, PA.
DIE PART DETAILS (F.E.)
FRANKFORD ARSENAL
DRAWN
TRACED
CHECKED
APPROVED
10-1-54
D-119845-2
DIE No
D-24955



HIGHLY POLISH BEFORE HARDENING & AFTER
MUST BE FREE OF NICKS, SCRATCHES
TOOL MARKS, & UNDERCUTS

7 PUNCH

MATERIAL - STAMINAL OHTS
HARDEN - Rc 59-60

A	JER	1.686 WAS 1.621	1-31-55	F
B	JER	1.011 WAS 1.023 ±.001	2-3-55	G
C	JER	.938 WAS .950 ±.001	2-3-55	H
D				J
E				K

HEINTZ MFG. CO.
PHILADELPHIA, PA.

JER 1-4-55

DIE PART DETAILS (F.E.)
30MM, T306E10 - F.D. 18083
FRANKFORD ARSENAL

D-119845-3

DIE No. D-24955

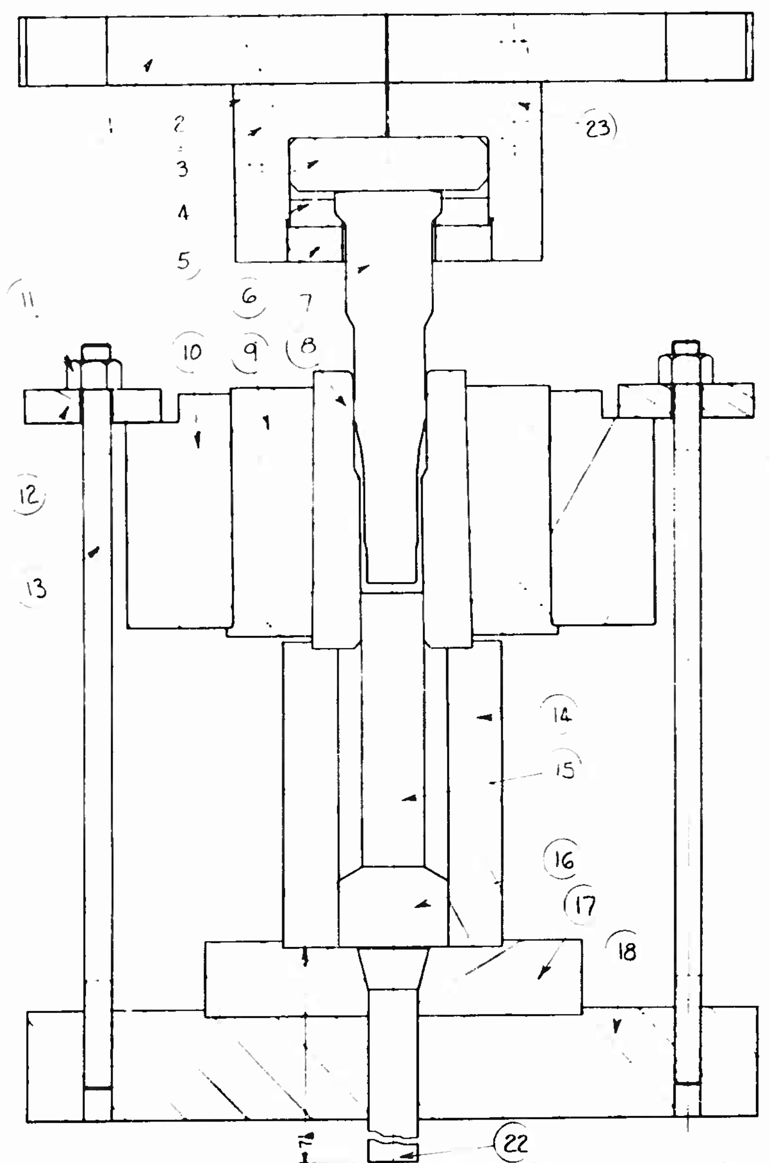
FILE NO. | CHANGE

12. FIRST DRAW AND COIN

This press operation formed the cavity shape and reduced the outside diameter by drawing the metal in against the punch in the lower section and ironing the upper wall.

Drawing, of course, introduced tensile stress in the piece and tended to make the bottom of the piece slightly curved. A coining operation, which consisted simply of compressing the metal between the punch and knockout pin, at the end of the draw stroke, removed this curvature and produced a flat bottom of .165" plus or minus .003" as required. The press shut height was adjusted so that the distance from the draw angle to the bottom of the piece was 1-7/8".

The tooling used to form the metal as described is shown on Dwg #B-119846 which immediately follows this text. The operation was done on a 100 ton mechanical Verson press. The force actually necessary was 105 tons for coining. The draw load itself was only 11 tons.



BILL OF MATERIALS

See Note No	Detail Dwg No	Item	Qty	Qty	Rough Size
2		1	1	1	
2		2	1	1	
2		3	4	4	
2		4	1	1	
2		5	1	1	
2		6			
	D-119846-1	7			2¼ Dia × 7½ Lg [illegible]
	D-119846-1	8			3½ Dia × 6 Lg [illegible]
2		9			
2		10			
2		11	6	6	
2		12			
2		13			
2		14			
	D-119846-1	15			1½ Dia × 6 Lg [illegible]
2		16	1	1	
2		17	1	1	
2		18	1	1	
2		19			
2		20	2	2	
2		21	1	1	
2		22	1	1	
2		23	4	4	

NOTE:-

1- PARTS ITEM NOS 1, 2, 3, 4, 5, 6, — 9, 10, 11, 12, 13, 14 — 16, 17, 18, 19, 20, 21, 22, & 23 ARE **NOT** TO BE MADE FOR THIS DIE.

2- USE SIMILAR PARTS FROM DIE NO D 24294, DWG NO B 119824 & DETAILS

HEINTZ MFG. CO.
PHILADELPHIA, PA.

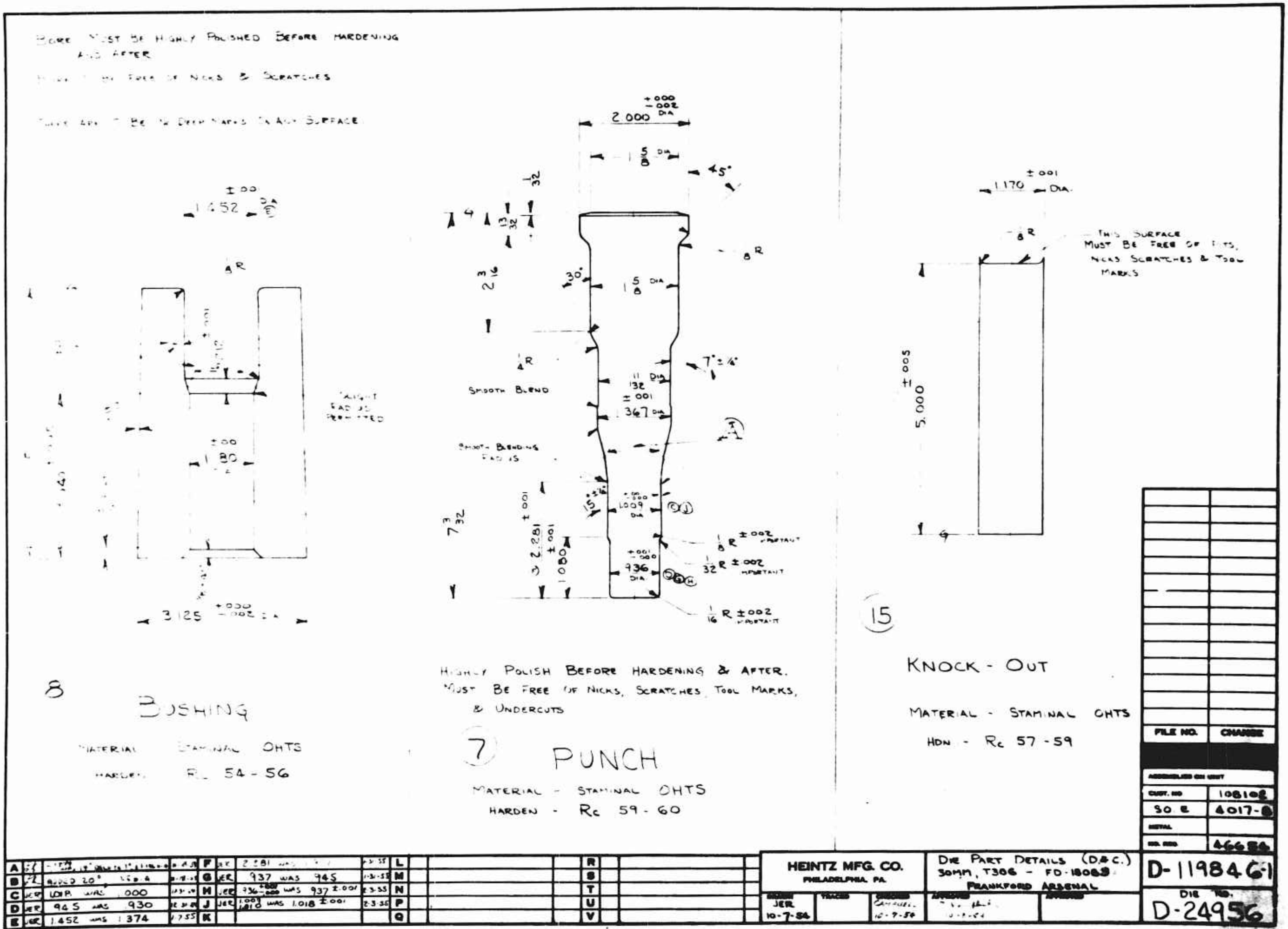
DRAW & COIN DIE
30MM. T306E10 - PD-10083
FRANKFORD ARSENAL

JER 10-6-54

108102
30. E 4017-B
46654

B-119846

DIE NO
D-24956



HIGHLY POLISH BEFORE HARDENING & AFTER. MUST BE FREE OF NICKS, SCRATCHES, TOOL MARKS, & UNDERCUTS
8
BUSHING
MATERIAL - STAMINAL OHTS
HARDEN - Rc 54 - 56
7
PUNCH
MATERIAL - STAMINAL OHTS
HARDEN - Rc 59 - 60
15
KNOCK - OUT
MATERIAL - STAMINAL OHTS
HDN - Rc 57 - 59
THIS SURFACE MUST BE FREE OF PITS, NICKS, SCRATCHES & TOOL MARKS
SMOOTH BLEND
SMOOTH BLENDING RADIUS
2.000 +.000 -.002 DIA
1.170 ±.001 DIA.
5.000 ±.005
1.452 ±.001 DIA
3.125 +.000 -.002 DIA
HEINTZ MFG. CO.
PHILADELPHIA, PA.
DIE PART DETAILS (D&C.)
30mm, T306 - FD-18069
FRANKFORD ARSENAL
JER
10-7-54
FILE NO.
CHANGE
CUST. NO
108102
SO E
4017-8
D-119846-1
DIE NO.
D-24956

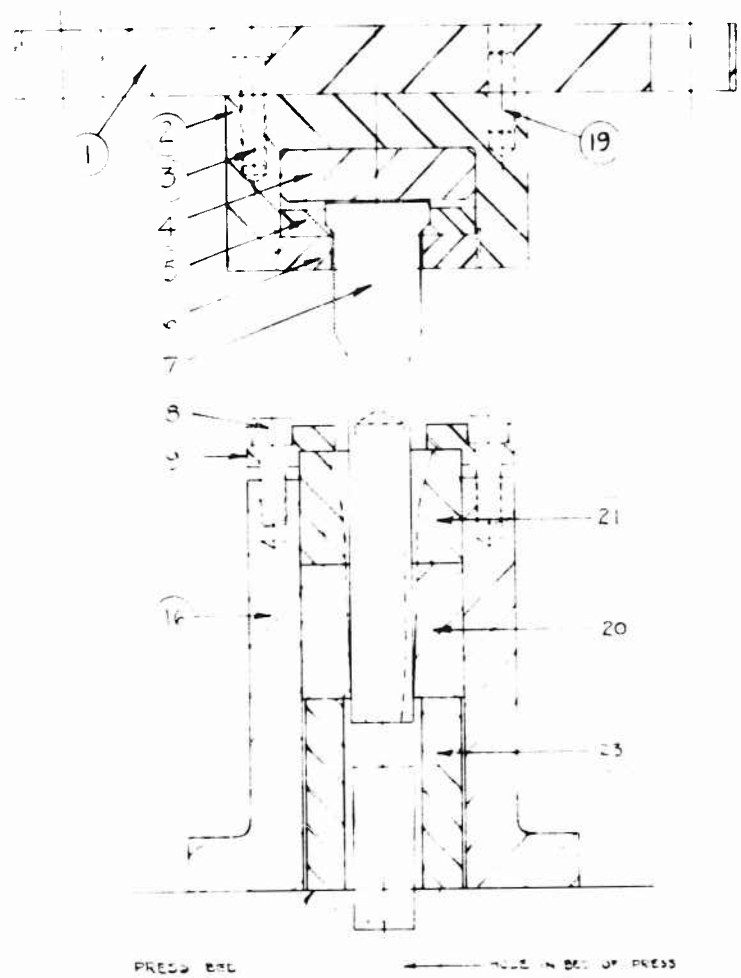
13. SECOND DRAW

This "draw" operation actually folded the metal in the large walled section at the open end into the inside of the piece, producing a uniform outside diameter.

Considerable difficulty was experienced with this operation. Any punch used to draw the piece through the die had to be small enough to be removed through the reduced inside nose diameter created by this operation. A punch of this diameter created a pressure on the inside bottom of the piece sufficient to malform it.

This problem was solved by making a very unique punch as shown on Dwg #119848. This punch pressed on the top of the piece and as it pushed through the die it collapsed to conform to the decreasing die diameter.

The necessary tools are shown on Dwg #119848. Only 44 tons were required to do this operation.



BILL OF MATERIALS

SEE NOTE NO.	DETAIL DWG NO	ITEM NO	[illegible]	[illegible]	ROUGH SIZE
1	D-119824-2	1		1	
1	D-119824-4	2	1	1	
1	B-119847	3	4	4	
1	B-114785-4	4		1	
1	B-114785-4	5	1	1	
1	B-114785-4	6	1	1	
	D-119848-1	7			2 ½ DIA x 10 LG - STAN [illegible]
1	D-119824-1	8	6	6	
1	E-119847-3	9	1	1	
	OMIT	10	1	1	
	"	11	1	1	
	"	12	1	1	
	"	13	1	1	
	"	14	1	1	
	"	15	1	1	
1	D-119847-1	16	1		
	OMIT	17	6	6	
	"	18	1	1	
1	D-119847	19	4	4	
	E-119847-5	20	1	1	
	D-119848-2	21			3 ¼ DIA x 2 ½ LG [illegible]
	OMIT	22	1		
	D-119848-3	23	1		3 ¼ DIA x 4 [illegible]

NOTE:-

1 PARTS ITEMS NO 1, 2, 3, 4, 5, 6, 8, 9, 16 & 19 ARE NOT TO BE MADE FOR THIS DIE

2 - USE WRENCH ASSEM FROM DIE NO 24224

HEINTZ MFG. CO. PHILADELPHIA, PA.

NOSE DIE 30MM T306E10 & 30MM T328 FRANKFORD ARSENAL

108107

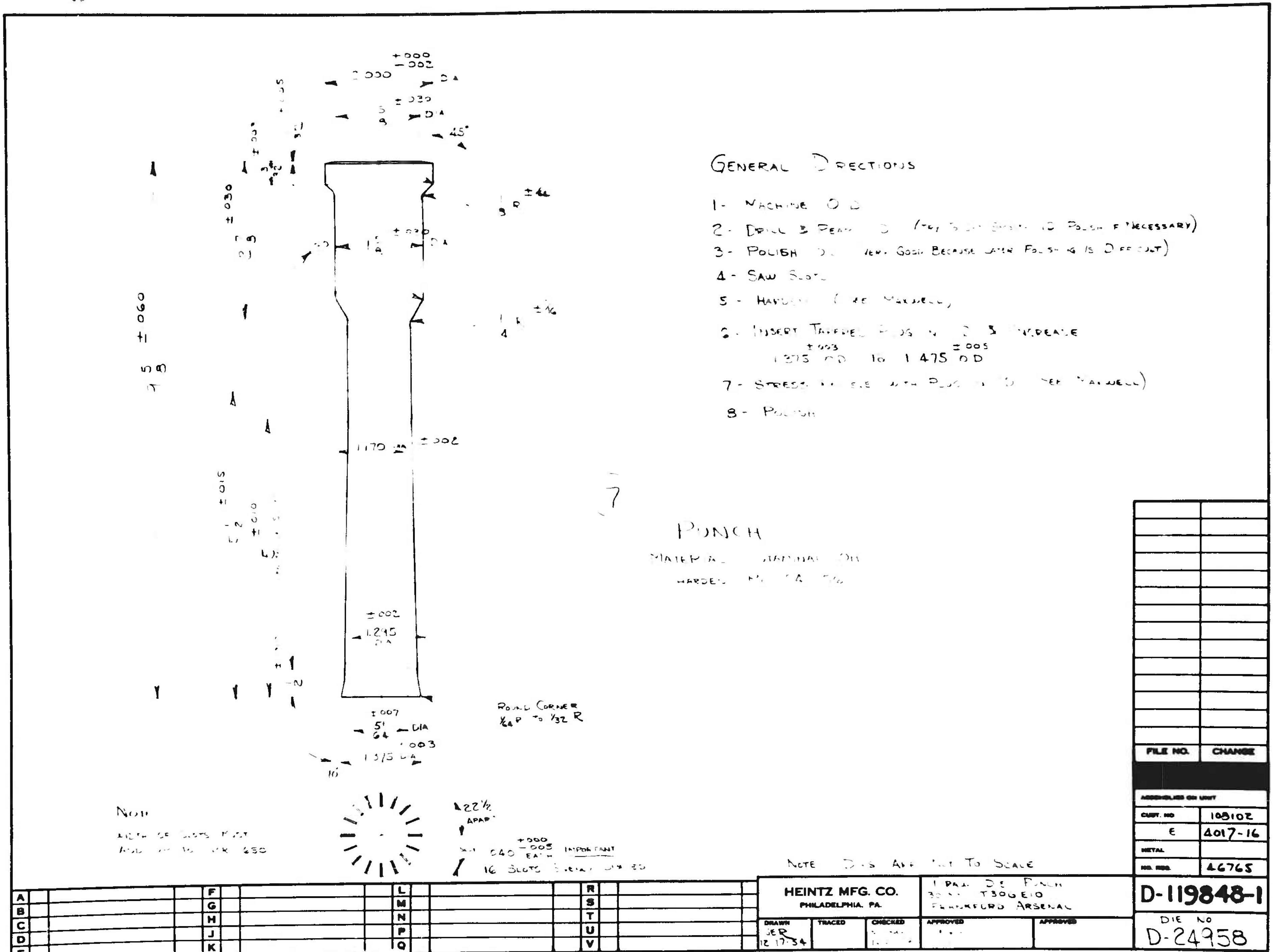
E4017-10

46681

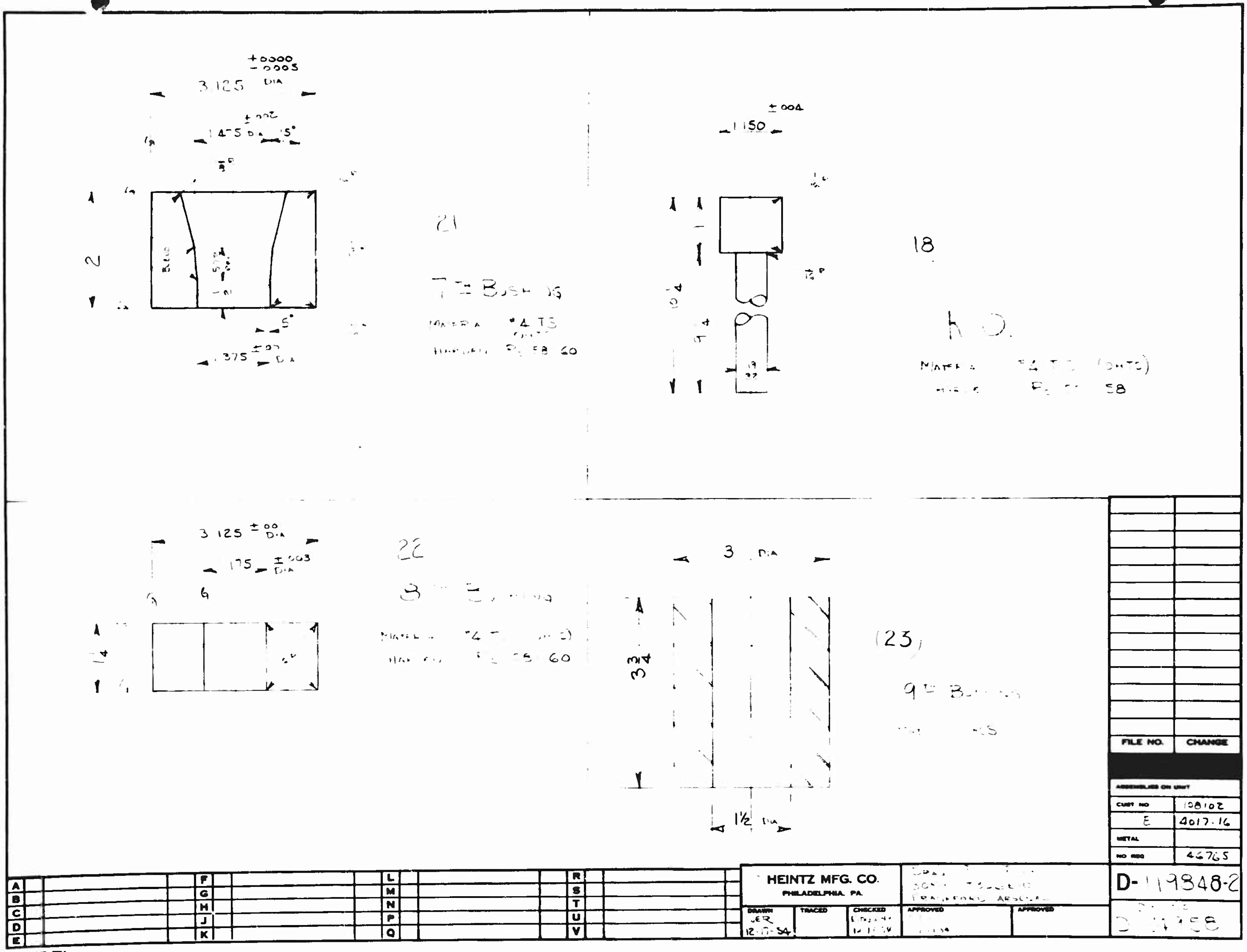
B-119848

DIE NO D-24958

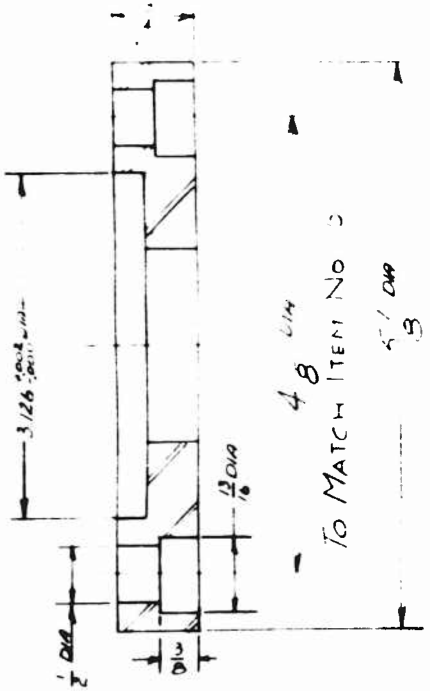
2-20-54



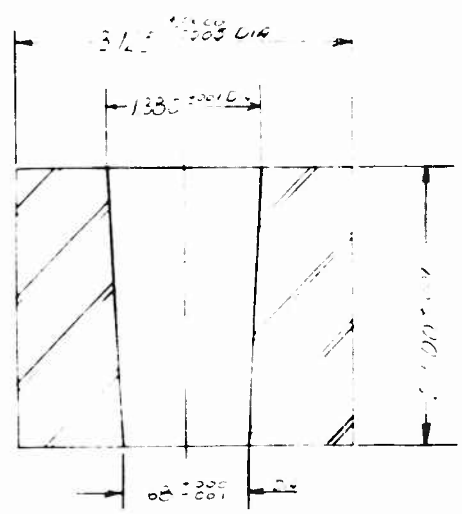
General Directions
1- Machine O D
2- Drill & Ream
3- Polish
4- Saw Slots
5- Harden
6- Insert Tapered
1.375 OD To 1.475 OD
7- Stress
8- Polish
Punch
Material
Round Corner
1/64 R to 1/32 R
22½° Apart
16 Slots
Important
Note
Note Dims Are Not To Scale
HEINTZ MFG. CO.
PHILADELPHIA, PA.
T30E10
Frankford Arsenal
Drawn
JER
12-17-34
Traced
Checked
Approved
File No.
Change
Assembled on Unit
Cust. No
108102
E
4017-16
Metal
No. Req.
46765
D-119848-1
Die No
D-24958



21
3.125 +.0000 -.0005 DIA
1.475 ±.002 DIA
2
.375 ±.02 DIA
5°
18
1.150 ±.004
19/32
22
3.125 ±.00 DIA
.175 ±.003 DIA
1/4
(23)
3 DIA
3 3/4
1 1/2 DIA
FILE NO.
CHANGE
CUST NO 108102
E 4017.16
METAL
NO REQ 46765
HEINTZ MFG. CO.
PHILADELPHIA, PA.
DRAWN JER 12-17-54
TRACED
CHECKED
APPROVED
D-119848-2
A B C D E
F G H J K
L M N P Q
R S T U V



(9) TOP RETAINER C.R.S.



BREAK ALL CORNERS 1/32 RAD

(20) SPECIAL ... – STAMINAL

GRIND ALL OVER & POLISH

FILE NO.	CHANGE
ASSEMBLIES ON UNIT	
CUST. NO	
METAL	
NO. REQ.	

HEINTZ MFG. CO.
PHILADELPHIA, PA.

DIE PART DETAILS / No. 61
20MM. T30 E 10 FD-18083
FRANKFORD ARSENAL

DRAWN	TRACED	CHECKED	APPROVED	APPROVED
		JER 1-3-55	T.P.K. 1-3-55	

E-112647-3

DIE No. D-24957

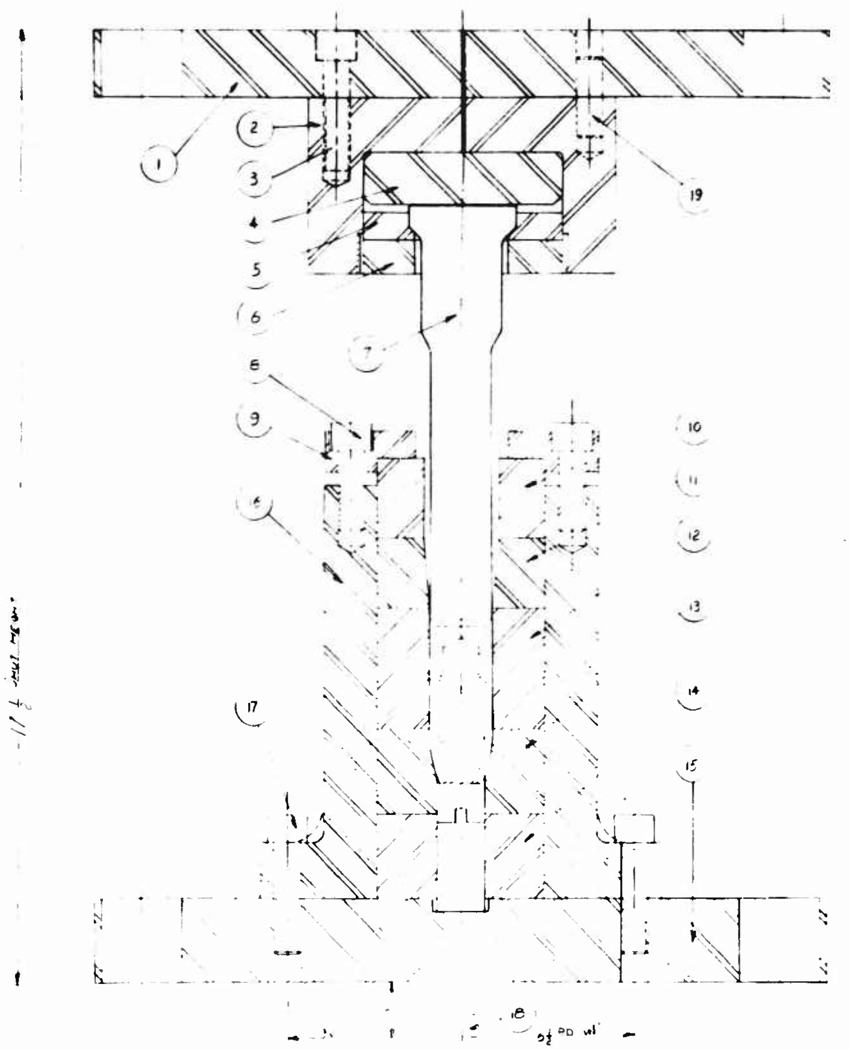
A		F	
B		G	
C		H	
D		J	
E		K	

14. NOSE

The tools required to nose this shell are shown on Dwg #B-119847 which immediately follows.

The cylindrical piece previously formed was placed mouth down in the die and forced to conform to the curved shape of the die as it was pushed down by the punch. The distance to which the piece was pushed into the die was determined by the overall length requirement of 2.750" to 2.770". The outside diameter was to be held between 1.170" and 1.176".

This operation was performed using a 100 ton mechanical Verson press. Only twenty tons were actually necessary to nose this piece.



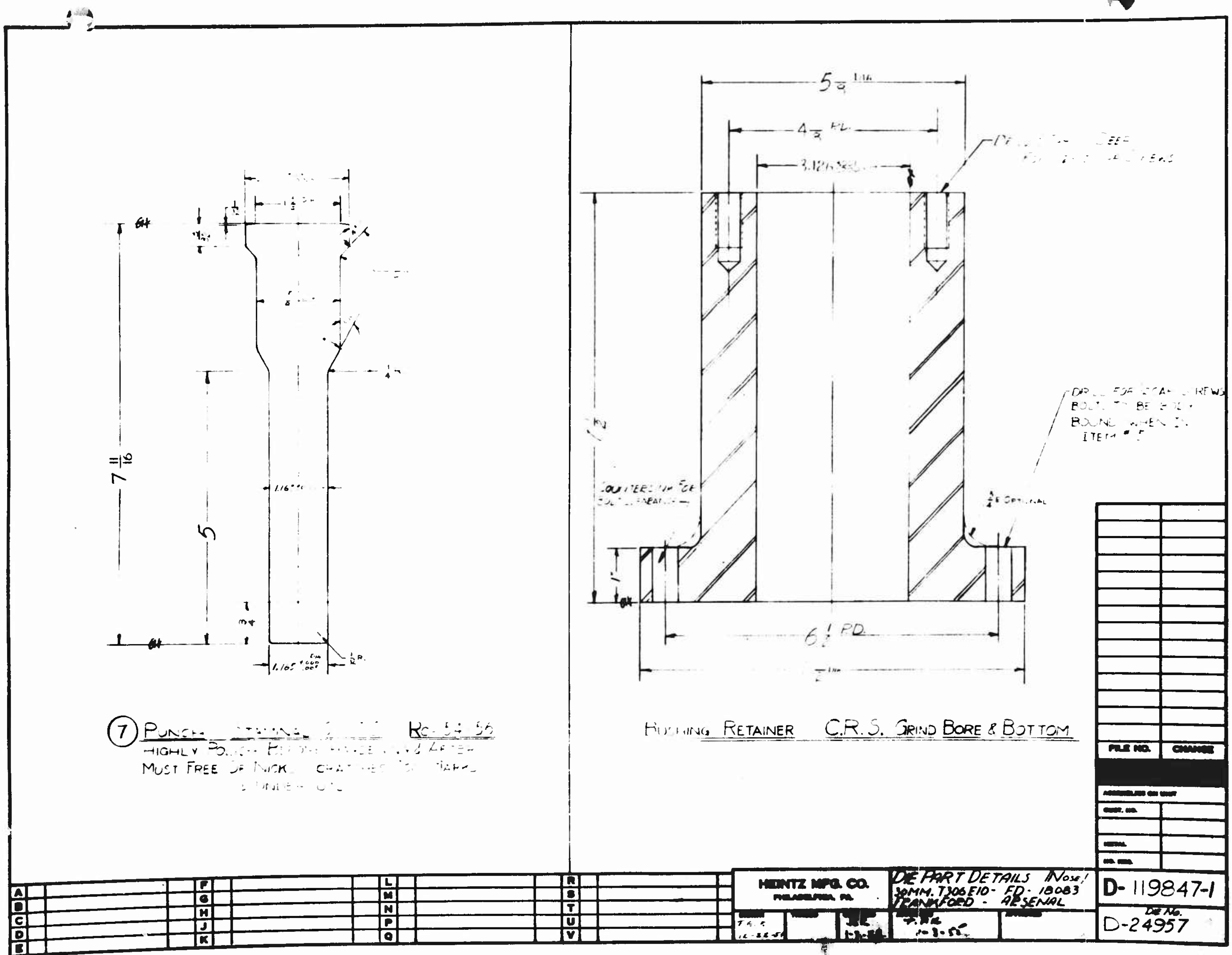
NOTE:-

1. Parts Item No 1 2 3 4 5 6 ... ARE **NOT** TO BE MADE FOR THIS DIE
2. ALTER ITEM NO 15 OF DIE NO 23104 TO ... AS ITEM NO 5 OF THIS DIE
3. ... WRENCH ASSEM FROM DIE NO 24294
4. SEE DETAIL DWG PART NOT SHOWN ON ASSEMBLY

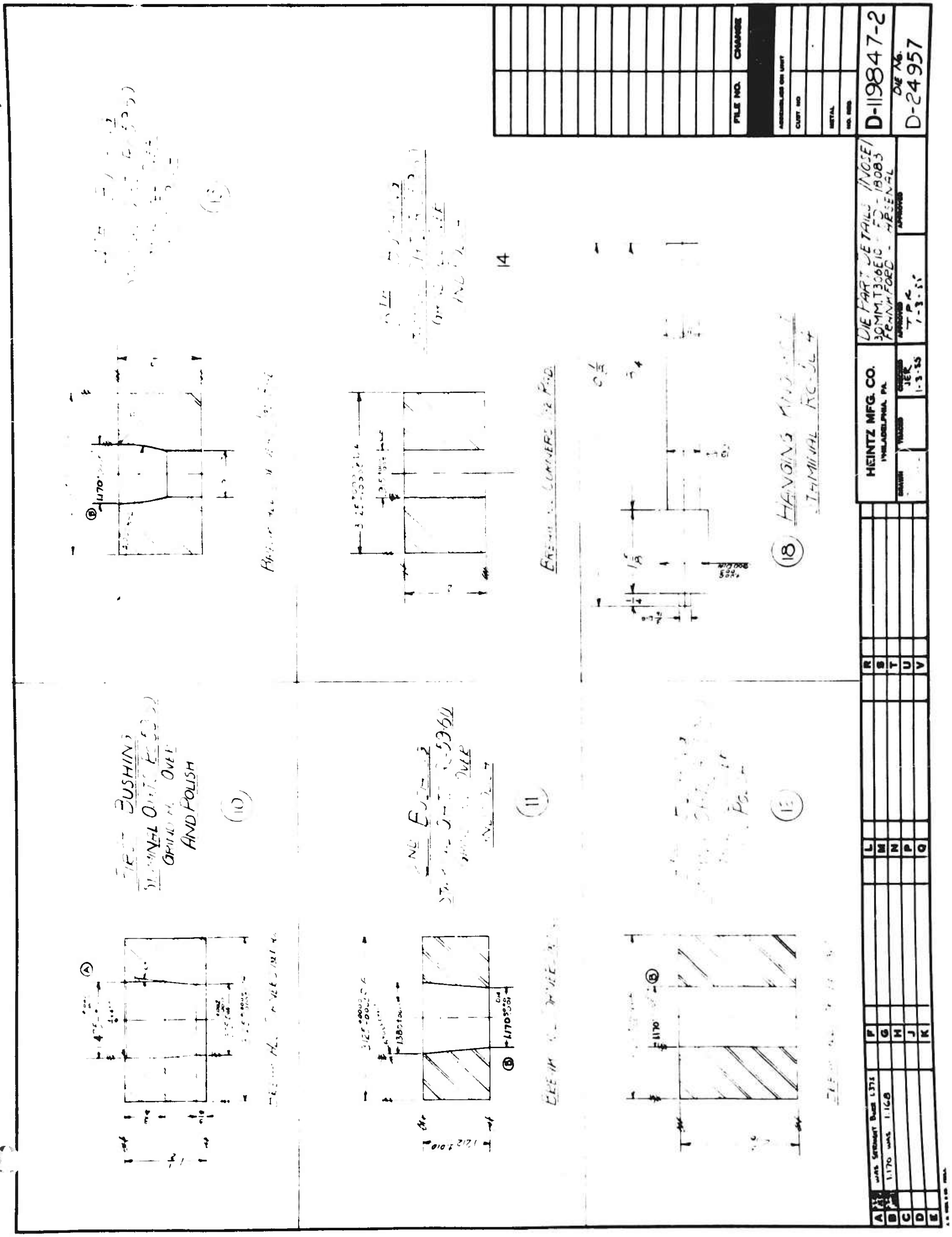
HEINTZ MFG. CO.
PHILADELPHIA, PA.

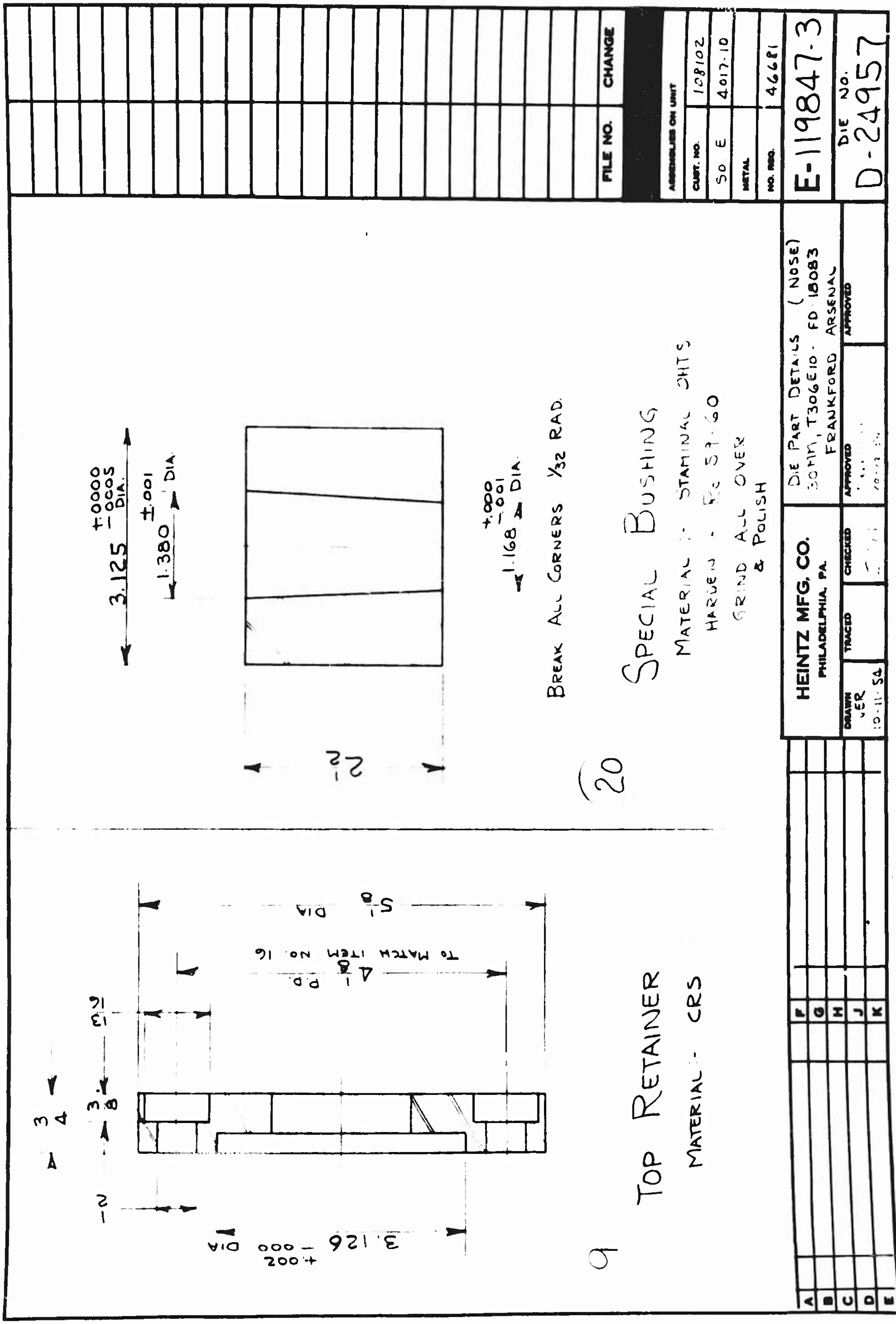
B-119847

D-24957



7 PUNCH
Rc 54-56
HIGHLY POLISH
MUST FREE OF NICK
BUSHING RETAINER C.R.S. GRIND BORE & BOTTOM
HEINTZ MFG. CO.
PHILADELPHIA, PA.
DIE PART DETAILS NOSE!
30MM. T306E10- FD- 18083
FRANKFORD - ARSENAL
D-119847-1
DE No.
D-24957


HEINTZ MFG. CO.
PHILADELPHIA, PA.
DIE PART DETAILS (NOSE)
30MM. T306E10 - FD - 18083
FRANKFORD - ARSENAL
D-119847-2
DIE No.
D-24957
BUSHING
GRIND H. OVER
AND POLISH
HANGING MANDREL
FILE NO.
CHANGE



FILE NO.
CHANGE
ASSEMBLIES ON UNIT
CUST. NO. 108102
SO E 4017-10
METAL
NO. REQ. 46681
E-119847-3
DIE No. D-24957
DIE PART DETAILS (NOSE)
30MM, T306E10 - FD 18083
FRANKFORD ARSENAL
HEINTZ MFG. CO.
PHILADELPHIA, PA.
DRAWN JER 10-11-54
TRACED
CHECKED
APPROVED
A B C D E F G H J K
3.125 +.0000 −.0005 DIA.
1.380 ±.001 DIA
1.168 +.000 −.001 DIA
BREAK ALL CORNERS 1/32 RAD.
SPECIAL BUSHING
HARDEN - Rc 57-60
GRIND ALL OVER & POLISH
2 1/2
20
5 1/8 DIA
4 1/8 P.D. TO MATCH ITEM NO. 16
3/16
3/4
3/8
1/2
3.126 +.002 −.000 DIA
TOP RETAINER
MATERIAL - CRS
9

15. STRESS RELIEVE

After considerable experimental work a temperature of 700° F. was found to be the desired stress relief temperature. The pieces were heated in a Lindberg Electric Furnace and held for one and one-half (1-1/2) hours at this temperature and then air cooled.

BODY, SHELL, HEI, 30MM, T306E10

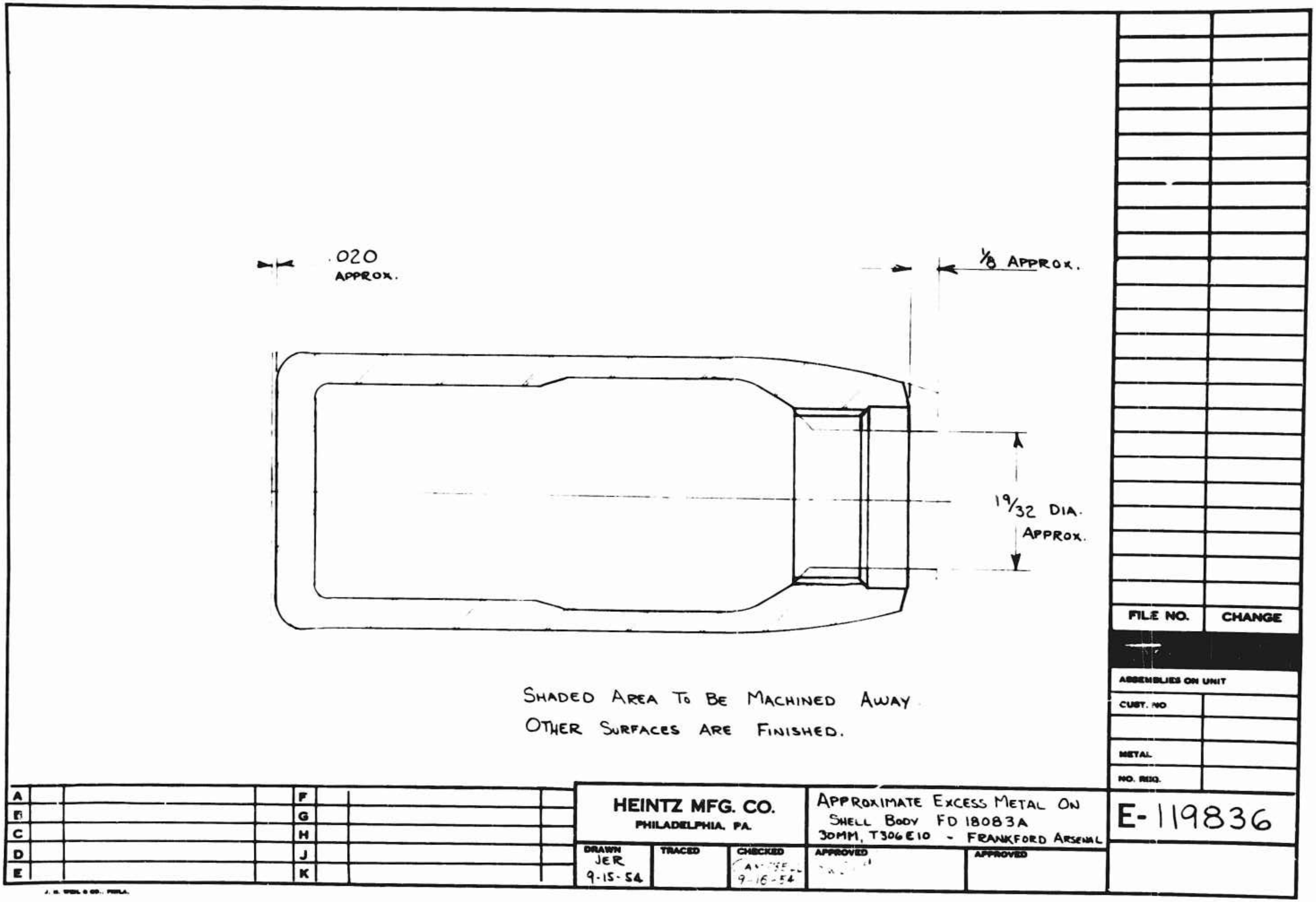
MACHINING AND FINISHING OPERATIONS

Operations necessary to finish the cold extruded shell, although conventional in nature, are recorded in detail hereafter. All of these operations were done at Pantex Manufacturing Corporation, Pawtucket, Rhode Island, on automatic equipment now in use to produce 30mm shell bodies from bar stock.

The operations were as follows:

1. Rough Face and Drill
2. Face, Drill and Recess Nose End of Shell
3. Machine 1/8" Radius at Junction of Outside Diameter and Base
4. Wash
5. Tap 3/4"-20 thread
6. Wash
7. Spot Weld Base Plate
8. Inspect
9. Pack

A sketch showing the cold extruded blank prior to machining and indicating the metal to be removed is shown on the following page.


.020 APPROX.
1/8 APPROX.
19/32 DIA. APPROX.
SHADED AREA TO BE MACHINED AWAY
OTHER SURFACES ARE FINISHED.
HEINTZ MFG. CO.
PHILADELPHIA, PA.
APPROXIMATE EXCESS METAL ON SHELL BODY FD 18083A 30MM, T306E10 - FRANKFORD ARSENAL
DRAWN JER 9-15-54
TRACED
CHECKED 9-16-54
APPROVED
APPROVED
FILE NO.
CHANGE
ASSEMBLIES ON UNIT
CUST. NO
METAL
NO. REQ.
E-119836

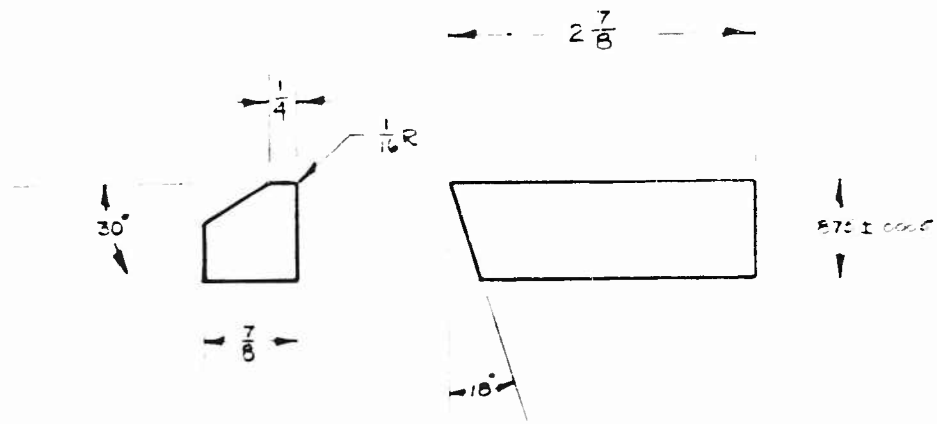
1. ROUGH FACE AND DRILL

This operation was performed in a 1-1/2 x 8 Conematic Chucker Serial No 3319WW. The details pertinent to this operation are shown below in tabular form. Tool drawings are found on the pages immediately following this text.

Steel Spec.	SAE 1021	Spindle Gears	33/39
Collet Size	1-3/16	Feed Gears	24/54
SSFPM	100	Tool Slide Cam Rise	5/8
Spindle RPM	361	Front Cross Slide Cam Rise	1/4
Cycle	16	Rear Cross Slide Cam Rise	0
Hourly Production	126		

POS	TOOL SLIDE OPERATIONS	POS	CROSS SLIDE OPERATIONS
1		1	
2		2	
3		3	Face with T312E1-T-25 tool in T-158-T-9 holder
4		4	
5		5	
6		6	
7	Insert shell with auxiliary arm (standard)	7	Mount gravity feed magazine (standard)
8	Drill cavity to 5/8 dia. with standard 5/8 three lip stub drill	8	

As a coolant a 20:1 mixture of Houghton Antisep All Purpose Base and water was used.



MAKE OF H.S.S - HARDEN Rc 63-65 & GRIND

FOR MACHINING
30 MM SHELL

FILE NO.	CHANGE
[redacted]	
ASSEMBLIES ON UNIT	
CUST NO	
DETAIL	
NO REQ	

HEINTZ MFG. CO.
PHILADELPHIA, PA.

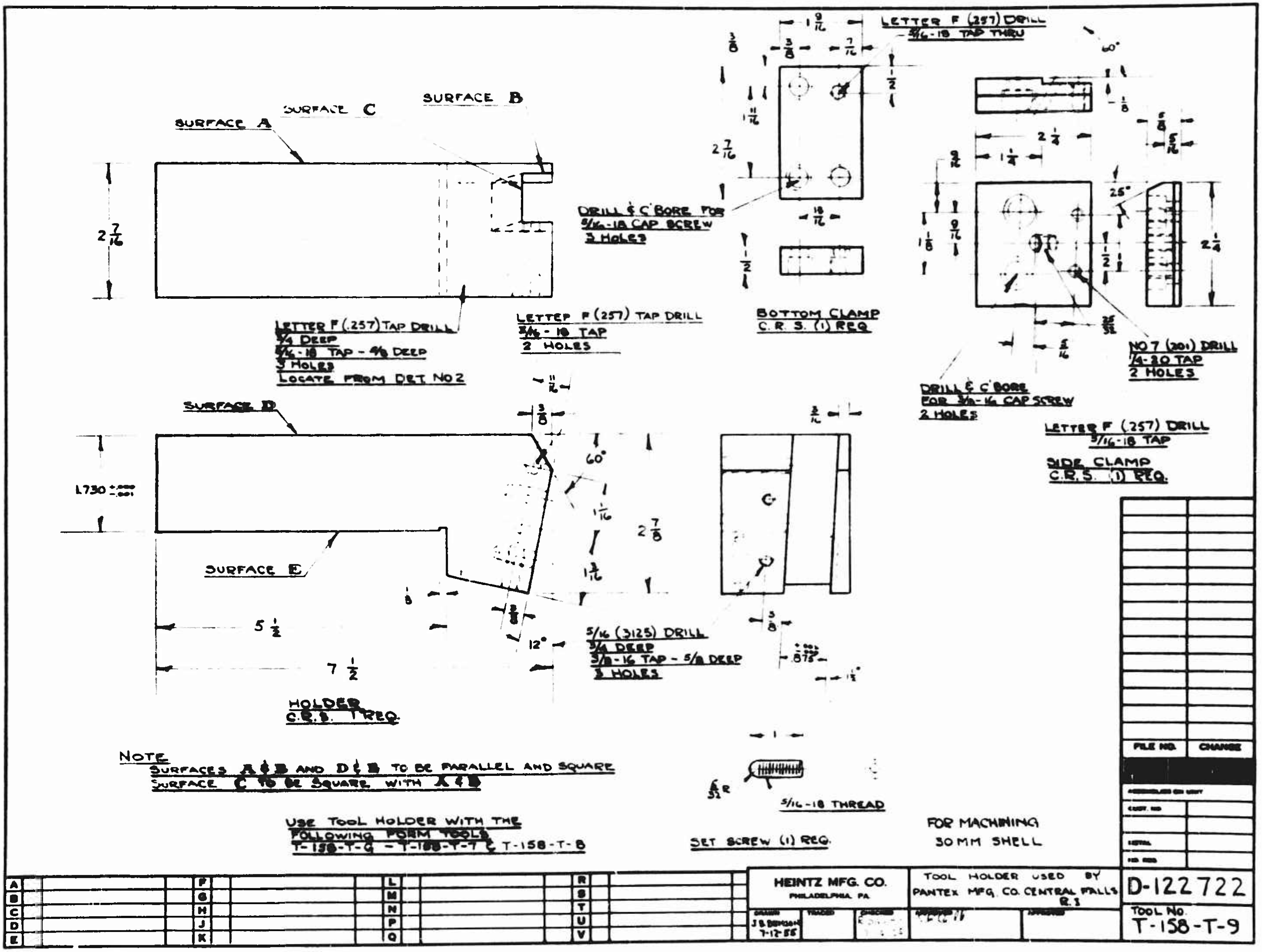
BREAK DOWN TOOL USED BY PANTEX MFG. CO. CENTRAL FALLS R.I.

DRAWN	TRACED	CHECKED	APPROVED	APPROVED
J B BENSON 7-11-55				

E-122730

TOOL No.
T312E1-T-25

A B C D E F G H J K



SURFACE A
SURFACE C
SURFACE B
LETTER F (.257) TAP DRILL
3/4 DEEP
5/16-18 TAP - 9/16 DEEP
3 HOLES
LOCATE FROM DET NO 2
LETTER F (257) TAP DRILL
5/16-18 TAP
2 HOLES
SURFACE D
SURFACE E
HOLDER
C.R.S. 1 REQ.
5/16 (3125) DRILL
3/4 DEEP
3/8-16 TAP - 5/8 DEEP
3 HOLES
LETTER F (257) DRILL
5/16-18 TAP THRU
DRILL & C'BORE FOR
5/16-18 CAP SCREW
2 HOLES
BOTTOM CLAMP
C.R.S. (1) REQ
NO 7 (201) DRILL
1/4-20 TAP
2 HOLES
DRILL & C'BORE
FOR 3/8-16 CAP SCREW
2 HOLES
LETTER F (257) DRILL
5/16-18 TAP
SIDE CLAMP
C.R.S. (1) REQ.
5/16-18 THREAD
SET SCREW (1) REQ.
NOTE
SURFACES A & B AND D & E TO BE PARALLEL AND SQUARE
SURFACE C TO BE SQUARE WITH A & B
USE TOOL HOLDER WITH THE
FOLLOWING FORM TOOLS
T-158-T-6 - T-158-T-7 & T-158-T-8
FOR MACHINING
30 MM SHELL
FILE NO.
CHANGE
HEINTZ MFG. CO.
PHILADELPHIA PA
TOOL HOLDER USED BY
PANTEX MFG. CO. CENTRAL FALLS R.I.
J.B. BENSON
7-12-55
D-122722
TOOL NO.
T-158-T-9

2. FACE, DRILL AND RECESS NOSE END OF SHELL

This machining was done on a 1-1/2" Conematic Chucker, Serial No 3319WW. The pertinent details such as speed, feeds, tools, etc., are shown in tabular form below:

Steel Spec.	1021	Spindle Gears	33/39
Collet Size	1-3/16	Feed Gears	38/40
SSFPM	100	Tool Slide Cam Rise	5/8
Spindle RPM	361	Front Cross Slide Cam Rise	1/4
Cycle	35	Rear Cross Slide Cam Rise	0
Hourly Production	60		

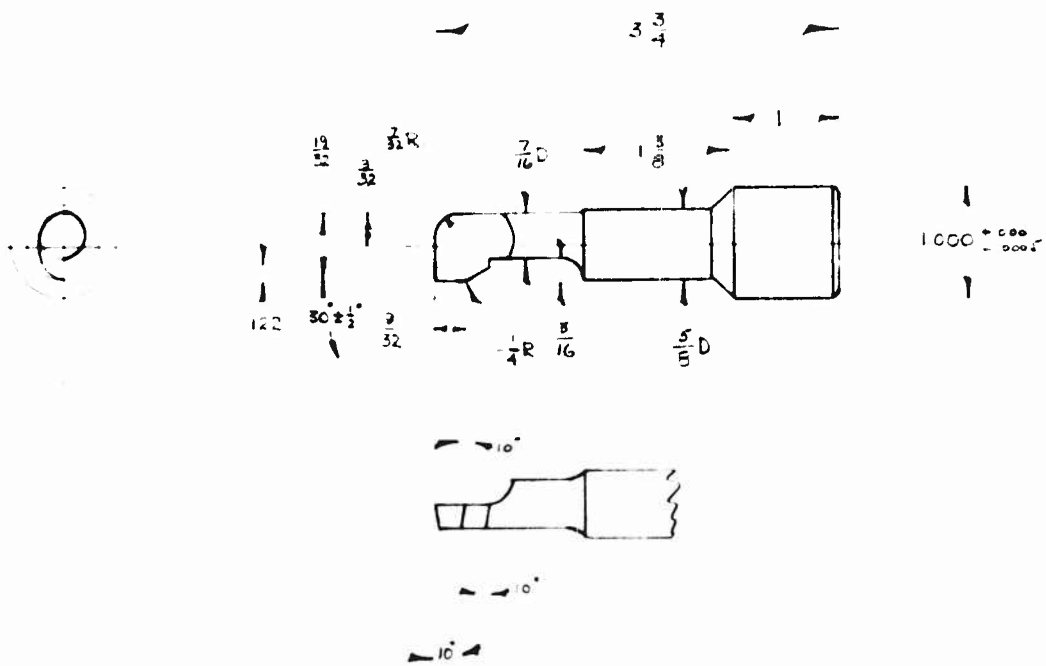
POS	TOOL SLIDE OPERATIONS	POS	CROSS SLIDE OPERATIONS
1	Drill .770 c/b dia. (rough) with st'd 3/4 three lip stub drill	1	
2	Drill (rough) minor pitch dia. with st'd 11/16 three lip stub drill	2	Rough face 15° angle with T312E1-T-25 breakdown tool in T158-T-9 holder
3	Ream .770 c/b dia. finish with st'd 25/32 dia. six flute stub reamer (ground to .774 dia.)	3	Finish face 15° angle with T-158-T-5 blade in T-158-T-11 tool holder
4	Recess with internal recessing attachment. Recessing tool T306E10-T-10	4	
5	Ream minor pitch dia. finish with st'd 23/32 dia. six flute reamer ground to .6995 dia.	5	
6		6	
7	Insert shell with st'd auxiliary arm	7	Mount standard gravity feed magazine
8		8	

2. FACE, DRILL AND RECESS NOSE END OF SHELL (Cont.)

The coolant was the E. F. Houghton Company's Antisep All Purpose Base mixed with water in the ratio of 20:1.

This machine was powered by a 25 HP, 220 volt, 60 cycle, 3 phase, 1750 RPM motor.

The tools are shown on the pages immediately following this text.



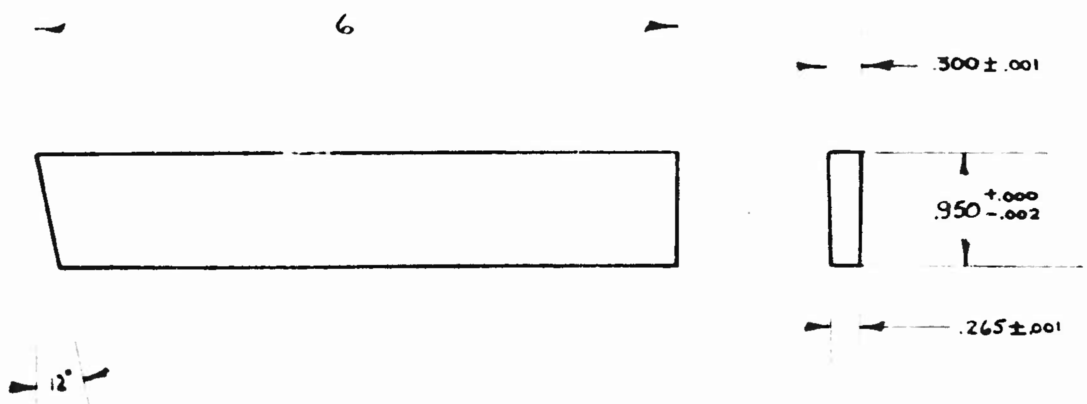
MAKE OF H.S.S HARDEN R_c 63-65 & GRIND

FOR MACHINING
30 MM SHELL

HEINTZ MFG. CO. PHILADELPHIA, PA.	FINISH BEHIND THREADS - TOOL PANTEX MFG. CO. CENTRAL FALLS R.I.	E-122725
DRAWN J B BENSON -11-55	APPROVED	TOOL No. T306E10-T-10
TRACED	APPROVED	
CHECKED		

FILE NO.	CHANGE
ASSEMBLIES ON UNIT	
CUST NO	
METAL	
NO REQ	

A		F	
B		G	
C		H	
D		J	
E		K	



MAKE OF H.S.S. – HARDEN R_c 63-65 & GRIND.

FOR MACHINING
30 MM SHELL

HEINTZ MFG. CO.
PHILADELPHIA PA.

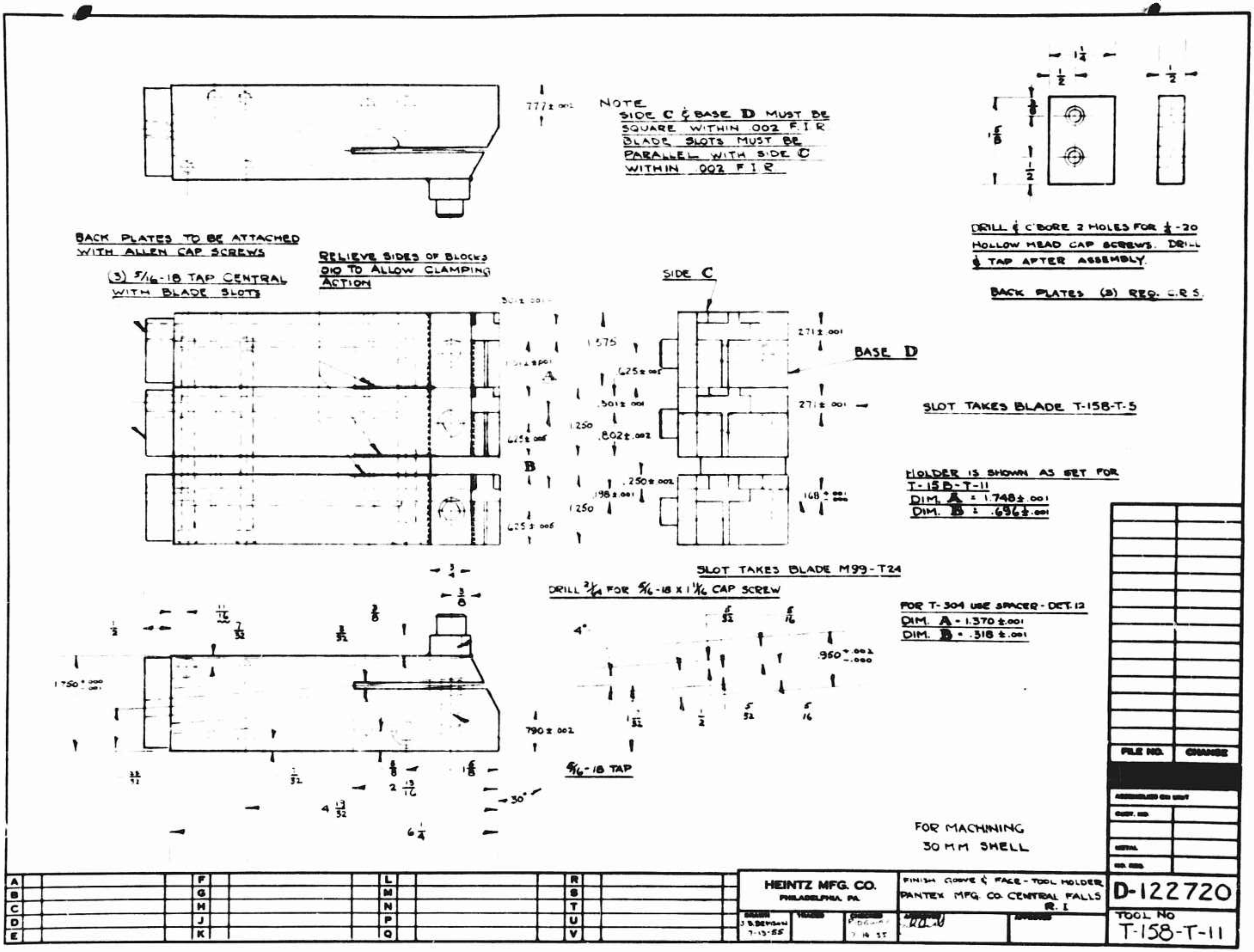
FINISH BAND GROOVE - TOOL
PANTEX MFG. CO. CENTRAL FALLS R.I.

DRAWN	TRACED	CHECKED	APPROVED	APPROVED
J. B. BENSON 7-11-55		RIDGWAY 7-14-55	[illegible]	

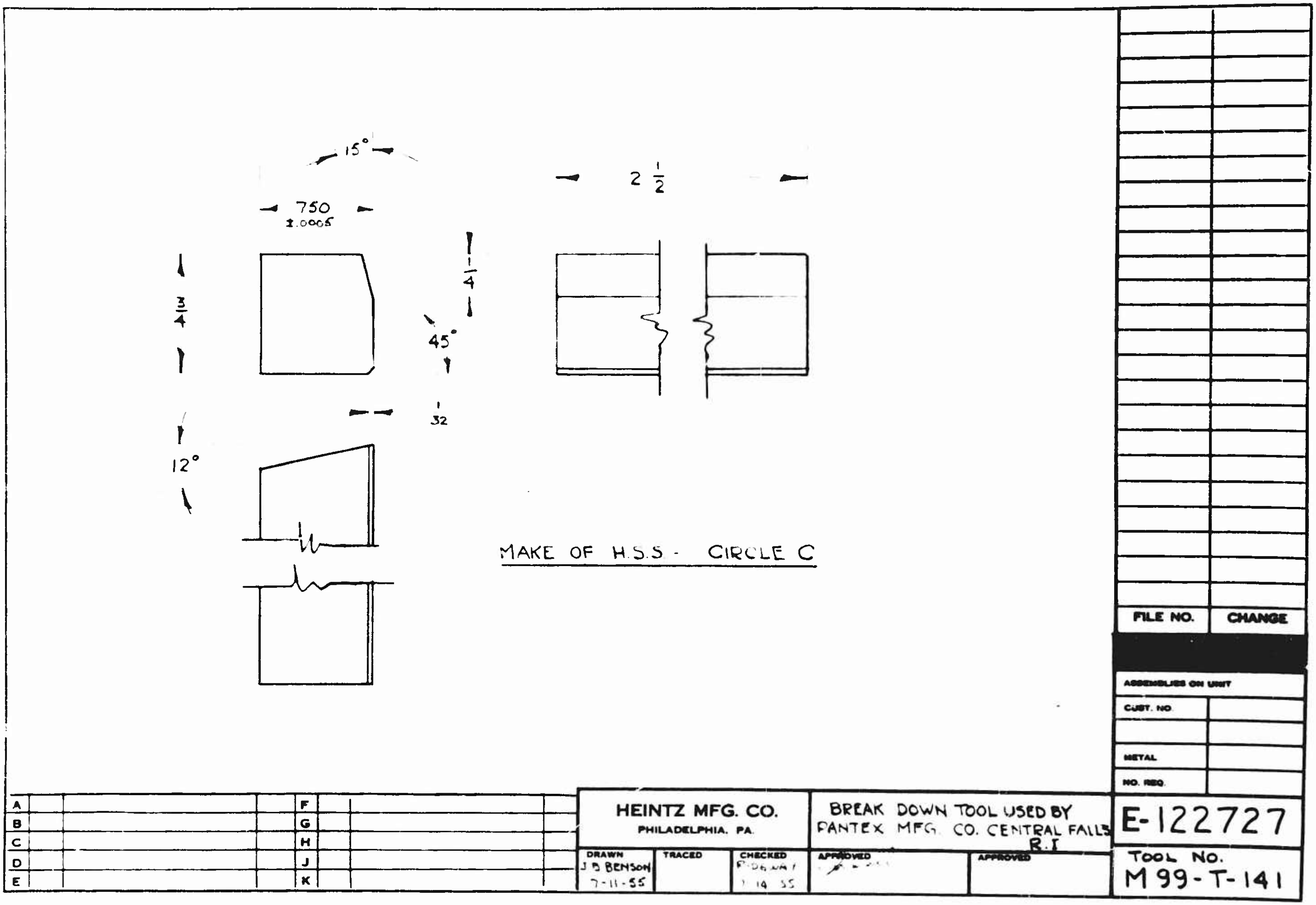
FILE NO.	CHANGE
ASSEMBLIES ON UNIT	
CUST. NO.	
METAL	
NO. REQ.	

E-122731

TOOL No
T-158-T-5



NOTE
SIDE C & BASE D MUST BE SQUARE WITHIN .002 F.I.R
BLADE SLOTS MUST BE PARALLEL WITH SIDE C WITHIN .002 F.I.R
BACK PLATES TO BE ATTACHED WITH ALLEN CAP SCREWS
(3) 5/16-18 TAP CENTRAL WITH BLADE SLOTS
RELIEVE SIDES OF BLOCKS .010 TO ALLOW CLAMPING ACTION
DRILL & C'BORE 2 HOLES FOR 1/4-20 HOLLOW HEAD CAP SCREWS. DRILL & TAP AFTER ASSEMBLY.
BACK PLATES (3) REQ. C.R.S.
SIDE C
BASE D
SLOT TAKES BLADE T-158-T-5
HOLDER IS SHOWN AS SET FOR T-158-T-11
DIM. A = 1.748 ± .001
DIM. B = .696 ± .001
SLOT TAKES BLADE M99-T24
DRILL 21/64 FOR 5/16-18 X 1 1/16 CAP SCREW
FOR T-304 USE SPACER - DET. 12
DIM. A - 1.370 ± .001
DIM. B - .318 ± .001
5/16-18 TAP
FOR MACHINING
30 MM SHELL
HEINTZ MFG. CO.
PHILADELPHIA, PA.
FINISH GROOVE & FACE - TOOL HOLDER
PANTEX MFG. CO. CENTRAL FALLS R.I.
D-122720
TOOL No
T-158-T-11
FILE NO.
CHANGE


15°
750
±.0005
3/4
1/4
45°
1/32
12°
2 1/2
MAKE OF H.S.S - CIRCLE C
FILE NO.
CHANGE
ASSEMBLIES ON UNIT
CUST. NO.
METAL
NO. REQ.
HEINTZ MFG. CO.
PHILADELPHIA, PA.
BREAK DOWN TOOL USED BY
PANTEX MFG. CO. CENTRAL FALLS R.I.
DRAWN
J B BENSON
7-11-55
TRACED
CHECKED
APPROVED
APPROVED
E-122727
TOOL NO.
M 99-T-141
A
B
C
D
E
F
G
H
J
K

3. MACHINE 1/8" RADIUS AT JUNCTION OF OUTSIDE DIAMETER AND BASE

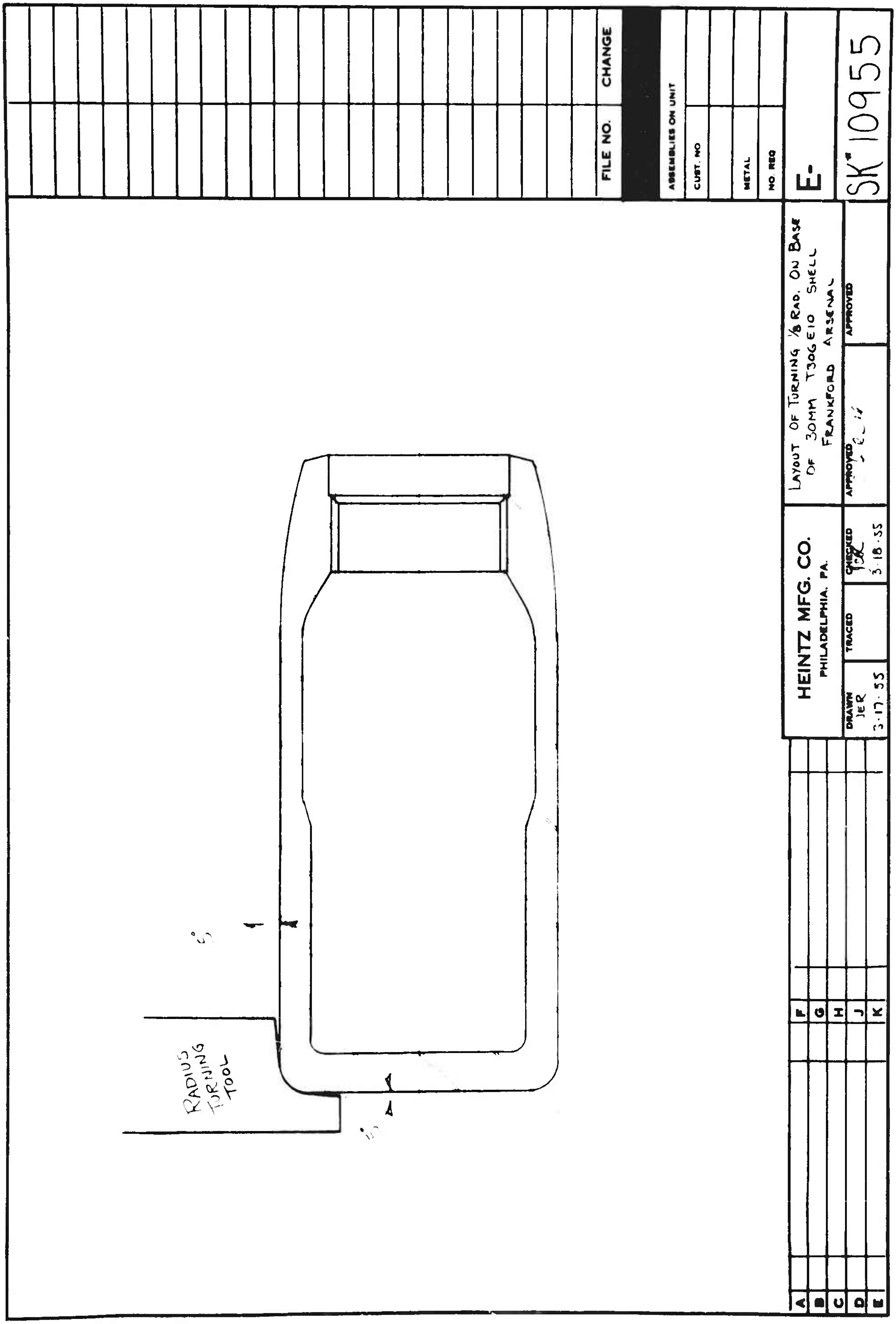
A Rapiduction Hand Screw Machine built by the Oster Manufacturing Company of Cleveland, Ohio, was used to form the radius.

The details of this machining setup are listed below in tabular form.

1.	Collet Size	1-3/16
2.	Spindle Speed	286 RPM
3.	Manual Cycle	
4.	Production Rate	150 pcs/hr

The machine was powered by a 4 HP, 220 volt, 60 cycle, 3 phase, 1700 RPM electric motor. A high speed tool bit 1/2" square by 4" long was used, ground according to Heintz SK #10955 which is shown on the page immediately following this text.

The operation was manual. The operator placed the piece in the collet, brought the tool against the shell until the radius was formed, then removed the tool, stopped the machine and removed the piece from the collet.



FILE NO.
CHANGE
ASSEMBLIES ON UNIT
CUST. NO
METAL
NO REQ
E-
SK# 10955
LAYOUT OF TURNING 1/8 RAD. ON BASE
OF 30MM T306E10 SHELL
FRANKFORD ARSENAL
APPROVED
APPROVED
HEINTZ MFG. CO.
PHILADELPHIA, PA.
DRAWN
JER
3-17-55
TRACED
CHECKED
3-18-55
RADIUS
TURNING
TOOL
A
B
C
D
E
F
G
H
J
K

4. WASH

The machine used was a Blakeslee Metal Parts Washer of a single stage conveyor type, serial No 1138, manufactured by G. S. Blakeslee & Company of Chicago, Illinois.

The pieces were placed open end down in welded wire baskets which held fifty (50) pieces each. As the pieces were carried through the machine by the conveyor they were sprayed with an emulsion cleaner and a rust inhibitor.

The chemicals used were NAMUL (emulsion cleaner) and SR-12 (rust inhibitor) which were manufactured by the Angler Chemical Company of Norton, Massachusetts.

The NAMUL was mixed in the ratio of one (1) gallon to one hundred seventy-five (175) gallons of water and the SR-12 was used at the ratio of four (4) ounces to one hundred seventy-five (175) gallons of water. The temperature of the spray was maintained at 175° F.

5. TAP 3/4"-20 THREAD

A Kaufman tapping machine, Serial #10-188, with a capacity of 5/8" to 1-1/8" manufactured by the L. J. Kaufman Manufacturing Company of Manitowok, Wisconsin, was used. The machine setup is listed below:

1.	Motor	3 HP, 220 volt, 3 phase, 60 cycle, 1725 RPM
2.	Coolant	Trifalex (undiluted)
3.	Production Rate	200 pcs/hr
4.	Spindle Speed	400 RPM
5.	Lead Screw	20 pitch, left hand

The operator placed two shell in the loading position of an eight station rotary table. The table then indexed and tapped two bodies simultaneously. While the machine operated, the operator removed two finished shell and replaced them with two new ones. The cycle was then repeated. An undiluted cutting oil manufactured by Trifalex Corporation of New York City was applied by brush to the area to be tapped.

6. WASH

This operation was identical to operation #4.

7. SPOT WELD BASE PLATE

A production welder manufactured by the Thomson-Gibb Electric Welding Company of Lynn, Massachusetts, welded the base plate to the bottom of the shell.

The machine specifications are listed below:

1. Thomson Production Welder, Type 19Z, Serial #15055

2. Electrical rating: 75 KVA, 60 cycle, primary voltage 220, primary current 341 amps, secondary current 42, 500 amps

3. Ignition timer: Westinghouse Electric Company's type SP 11B, 220 volt and 440 volt, 60 cycle, style 1106263.

The operator placed the shell open end down in a vise-like opening. A rubber centering device was placed on the piece and then the base plate was put into the cavity in the centering device. A switch was activated and the plate was welded in. The shell body was then removed and the cycle repeated.

8. INSPECT

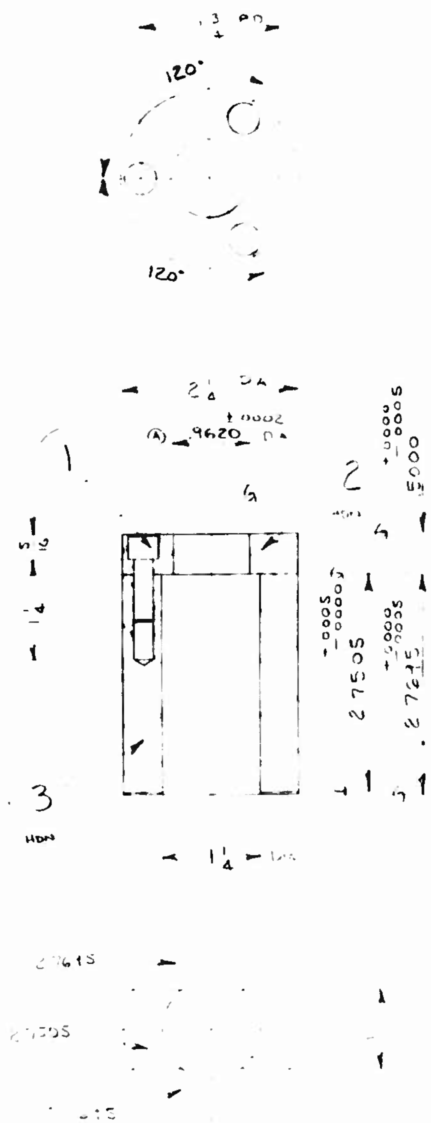
The following gages were used to check this shell body.

1.	Length gage (press)	J-15147
2.	Thread gages	J-15734
3.	1.176 dia. snap gage	J-15712
4.	2.77 overall length snap gage	J-15714
5.	.965 nose diameter	J-15716
6.	.920-.930 plug gage	J-15717
7.	.990-1.000 plug gage	J-15718
8.	.500 thread length gage	J-15721
9.	.6959/.7037 plug gage	J-15735

All of these gages are standard with the exception of Item #5 and 8, which are shown on the following pages.

BILL OF MATERIALS

NOTE	ITEM No.	No. OF PCS. ROUGH	No. OF PCS. FIN.	ROUGH SIZE
	1	3	3	1/4 DIA × 3/4 LG SOCKET HEAD CAP SCREWS
	2	1	1	2 1/2 DIA × 1 LG #1 TS
	3	1	1	2 1/2 DIA × 3 1/4 LG #1 TS



HARDEN & GRIND ALL PARTS

FILE NO.	CHANGE

ASSEMBLIES ON UNIT	
CUST. NO.	108102
SO E	4017-11
METAL	
NO. REQ.	46714

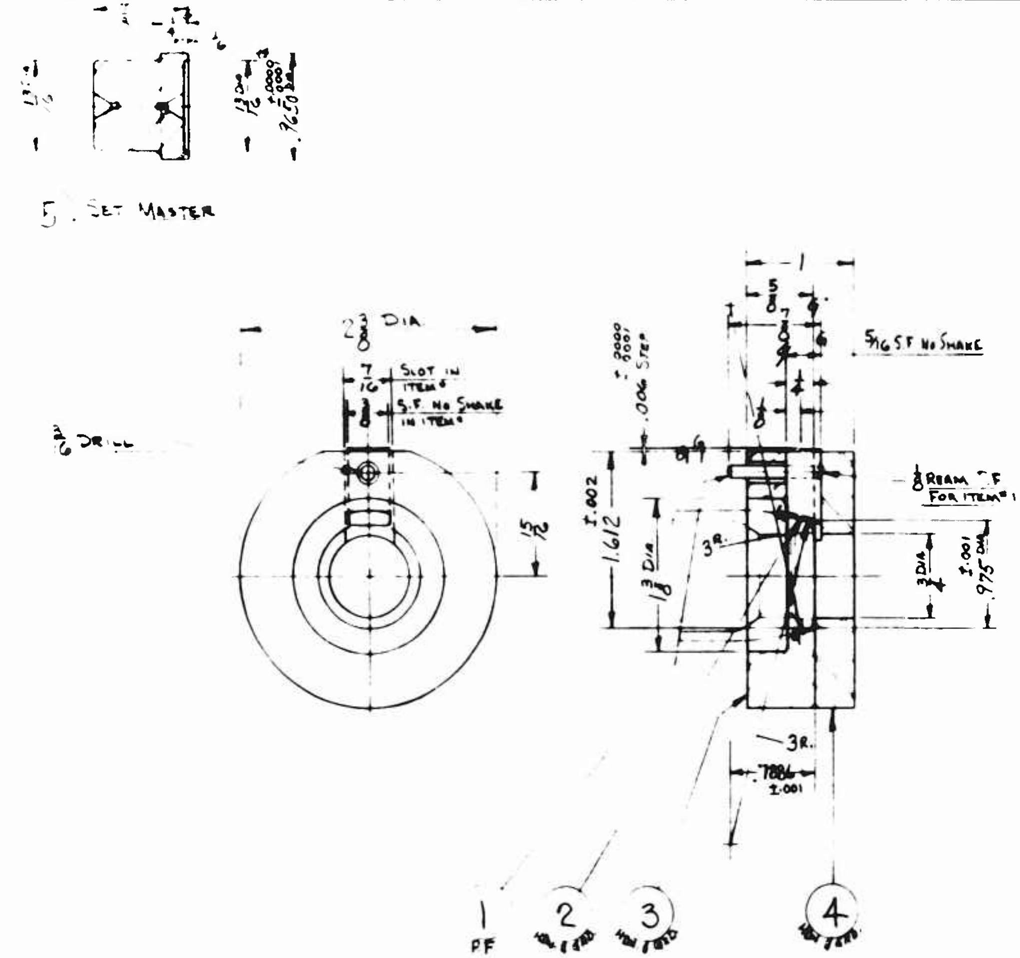
HEINTZ MFG. CO.
PHILADELPHIA, PA.

LENGTH GAGE
30MM. T306 E10
FRANKFORD ARSENAL

DRAWN JER 11-1-54 | TRACED | CHECKED | APPROVED | APPROVED

D- 121117

JIG NO
J-15147



ITEM No.	QUAN OF ROUGH PC.	QUAN OF FIN. PC.	ROUGH SIZE
1	1	1	DRILL ROD 1/8 DIA x 1 LG
2	1	1	DRILL ROD 1/2 SQ x 1 LG.
3	1	1	#4 T.S. 2 1/2 DIA. x 1 LG.
4	1	1	#4 T.S. 2 1/2 DIA. x 1/2 LG.
5	1	1	#4 T.S. 1 1/8 DIA. x 1 LG.

LIST OF MATERIALS

MARK TOO- No. PC No. & 30MM FA

BREAK ALL UNNECESSARY SHARP EDGES

± .0 ± .001 ± .5 MIN.

FILE NO.	CHANGE

ASSEMBLIES ON UNIT

CUST. NO PC 108102

S.O. E-4017-25

METAL

NO. REQ. No. 47291

HEINTZ MFG. CO.
PHILADELPHIA, PA.

GAGE TO CHECK .965 +.002 -.000 DIA
30MM T306 E10
FRANKFORD ARSENAL

DRAWN MO 3-10-55 | TRACED | CHECKED 3-10-55 | APPROVED T.P.K. 3-10-55 | APPROVED

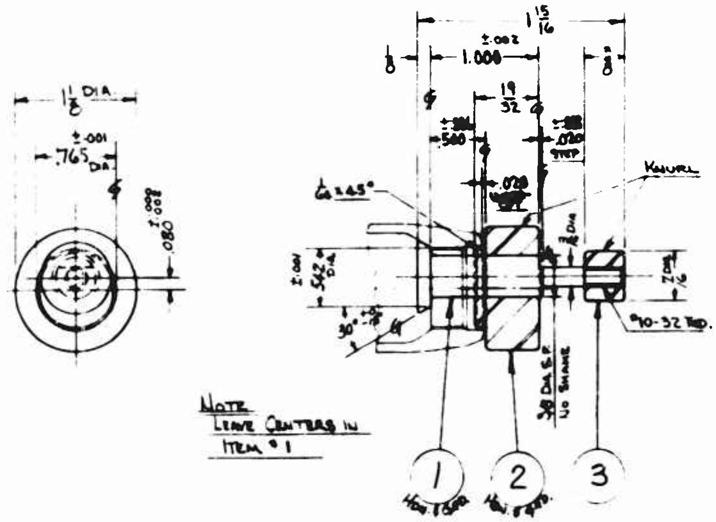
E-120474

J-15716

A			F		
B			G		
C			H		
D			J		
E			K		

List Of Materials

Item No	Quan. of Rough Pcs.	Quan. of Fin. Pcs.	Rough Size	
1	1	1	#4 T S	3/4 DIA. x 2 1/4 LG.
2	1	1	#4 T.S.	1 1/4 DIA. x 3/4 LG.
3	1	1	C.R.S.	7/16 DIA. x 1/2 LG.



NOTE
LEAVE CENTERS IN
ITEM #1

MARK TOOL No., Pc. No. & 30MM FA

BREAK ALL UNNECESSARY SHARP EDGES

FILE NO.	CHANGE

ASSEMBLIES ON UNIT

GUID. NO Pc.	108102
S.O.	E-4017-28
METAL	
REQ. No.	47296

HEINTZ MFG. CO.
PHILADELPHIA, PA.

GAGE TO CHECK .500 DIA.
30MM T306 E10
FRANKFORD ARSENAL

DRAWN	TRACED	CHECKED	APPROVED	APPROVED
ND 3-11-55				

E-120475

J-15721

A			F		
B			G		
C			H		
D			J		
E			K		

9. PACK

The pieces were packed according to specification MIL-P-10025A.

The box was made from 1/8" double faced corrugated cardboard and was 12-3/4" long by 6-3/8" wide by 9-1/4" deep and held one hundred (100) shell bodies in two layers of fifty each. The individual bodies were placed inside the spaces created by a 1/32" thick smooth cardboard separator. This separator was of the egg crate variety and formed pockets to hold five (5) shell along the width and ten (10) shell along the length of the box. A flat piece of 1/8" double face corrugated cardboard was used to separate the layers.

NOTE: In accordance with the instructions of the contract, these pieces were neither banded nor painted.

BODY, SHELL, HEI, 30MM, T306E10

METALLURGICAL DATA AND DISCUSSION

The mechanical properties required in this shell were a minimum yield strength of 90, 000 psi and an elongation of 10%.

This shell was made from the same 1-1/4" diameter AISI 1021 hot rolled bars as was used to make shell T241 and T304. The properties were identical and are repeated here for convenience only.

Chemical Analysis:

C	-	.19
Mn	-	.95
P	-	.018
S	-	.034
Su	-	.03

Structure: typical pearlite in a ferritic structure. Grain size 6-8.

Hardness: 70-80 R_B

After considerable experimental work had been performed it was agreed that a temperature of 700° F. produced the optimum results. The thinking and experimental work done was identical to that explained in detail on page 72.

The results of the tensile test obtained by pulling a flat specimen (see page 145) are listed below.

METALLURGICAL DATA AND DISCUSSION (Cont.)

Specimen	Tensile Strength	Yld. Str. (.1% Off)	Elong. in 1/2"	Hardness Range
3-2	98,500	94,100	12.5%	99-101
4-1	97,600	91,250	12.5%	99-101

Hardness patterns which indicate the extent of the strain hardening produced by the cold flow and the effect on the anneals are shown on the pages which immediately follow this text.

BY H. A. D. DATE

CHKD. BY .... DATE ....

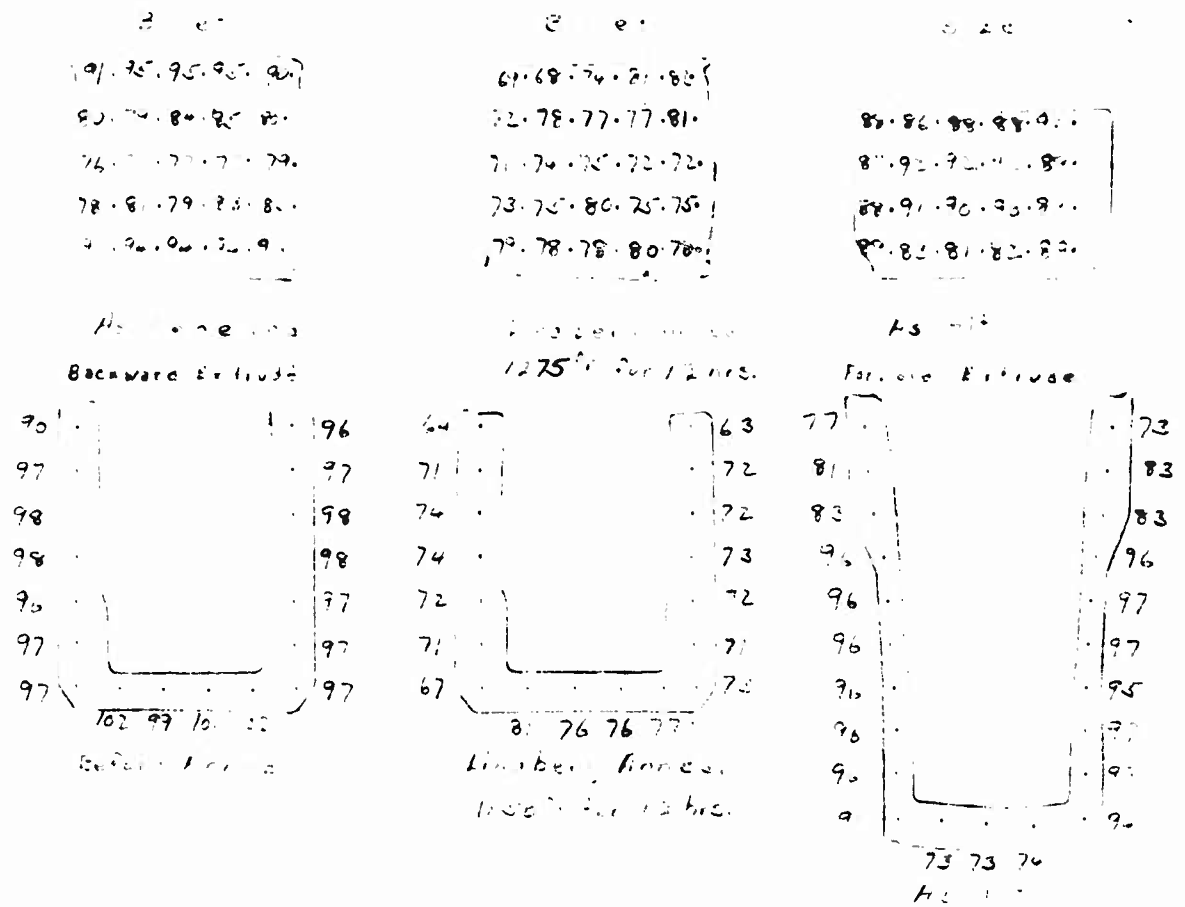
SUBJECT Hardness Survey

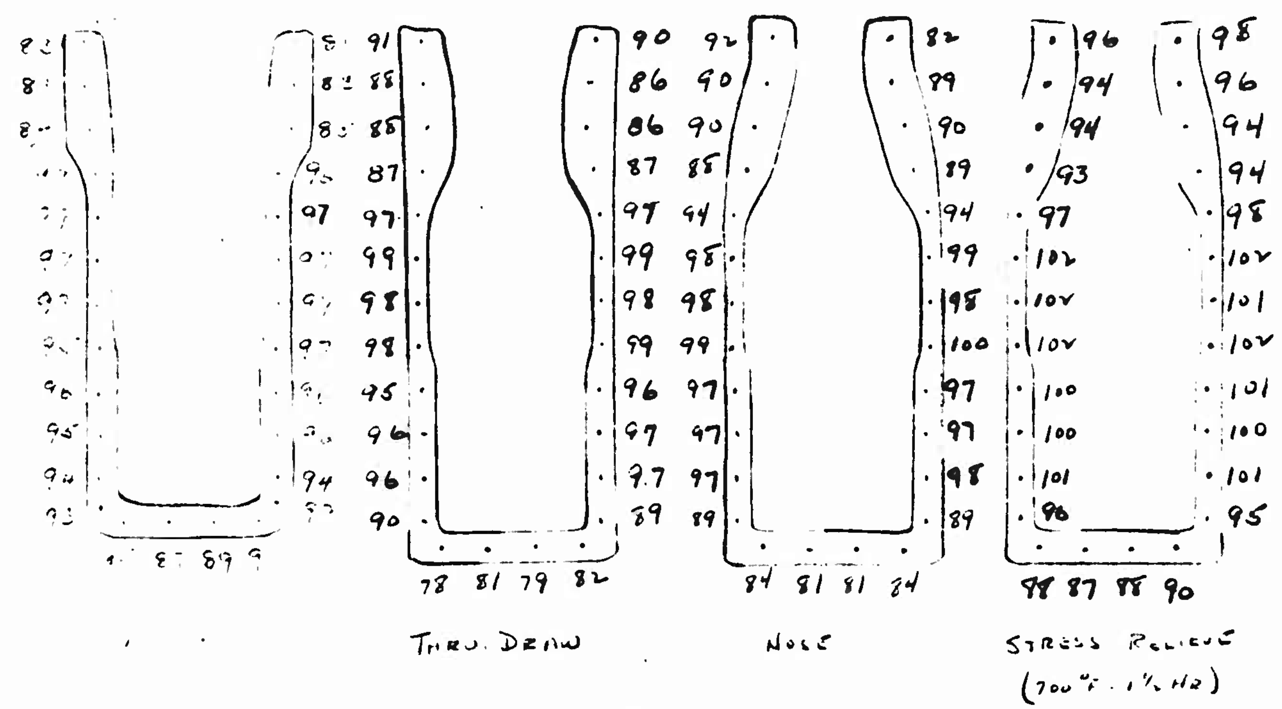
30mm T306 E10 steel 1021

Scale Rb HT 49N294

SHEET NO. .... OF ....

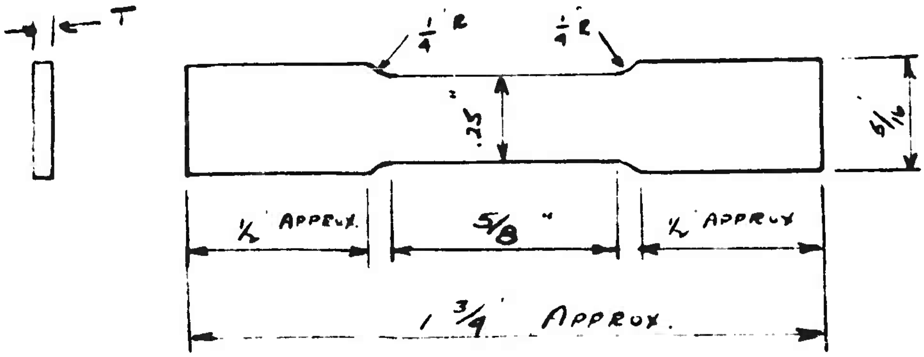
JOB NO V-43 37





BY Hlm DATE 11/8/54 SUBJECT Tensile Test Specimen SHEET NO. .... OF ....
CHKD. BY .... DATE .... JOB NO. ....

1/2" Gage Length Tensile Test Specimen (Flat)



Overall Length Of Specimen Dependent On Amount Of Metal Available In Piece From Which Specimen Is Made.

Faces Of Specimen To Be Ground Flat. Edges Of Test Section Must Be Free Of Scratches.

Thickness Of Specimen (T) Governed By Thickness Of Piece From Which Specimen Is Made. Should Include As Much Of Wall Thickness Of Piece As Possible.

PROJECTILE, TARGET PRACTICE, 30MM, T328

PROJECTILE, TARGET PRACTICE, 30MM, T328

ENGINEERING CONSIDERATIONS

This shell body was similar to the T241 and T304 shell previously discussed in that it apparently should be manufactured using successive backward extrusion operations to form the two inside diameters.

Two factors only would prohibit such a procedure--excessively high reductions in area which would induce high stresses in the tools, or extremely low reductions which would not work harden the material to the degree necessary to develop the required yield strength.

The 47% reduction in area necessary to form the .825" upper diameter was not excessive and was certainly more than required to achieve a yield strength of 90,000 psi. The forming of the .663" lower diameter was less severe but still sufficient to develop the required mechanical properties from 1021 steel.

When a backward extrusion like the one used to form the .825" diameter was contemplated some thought had to be given to the limitation on the depth of extrusion imposed by the character of the lubricant. The area of the top surface of the preceding piece was stretched by backward extrusion to form the cavity and in some instances this surface might be stretched locally as much as 800%.

As the depth of punch penetration increased, the surface metal and the lubricant increased in area. When this area increase thinned the coating too much it broke down, and the punch galled the workpiece.

This problem occurred when forming the upper diameter and it was necessary to extrude in two steps using an intermediate coating operation. In a special purpose surface treating operation, sufficient weight of coating probably could be applied to withstand the thinning produced by the total of these two operations.

Thus the basic forming operations consisted of three backward extrusions to form the cavity and outside diameter followed by a nosing operation to form the ogive.

Shearing was the most economical way to make billets from the bar stock, but it required an additional anneal to remove the effects of the severe cold work on the top and bottom surfaces, as well as a sizing operation to form the distorted slug into an acceptable shape for backward extrusion.

The basic sequence of operations was as follows:

1. Shear billets
2. Tumble
3. Anneal
4. Wheelabrate

ENGINEERING CONSIDERATIONS (Cont.)

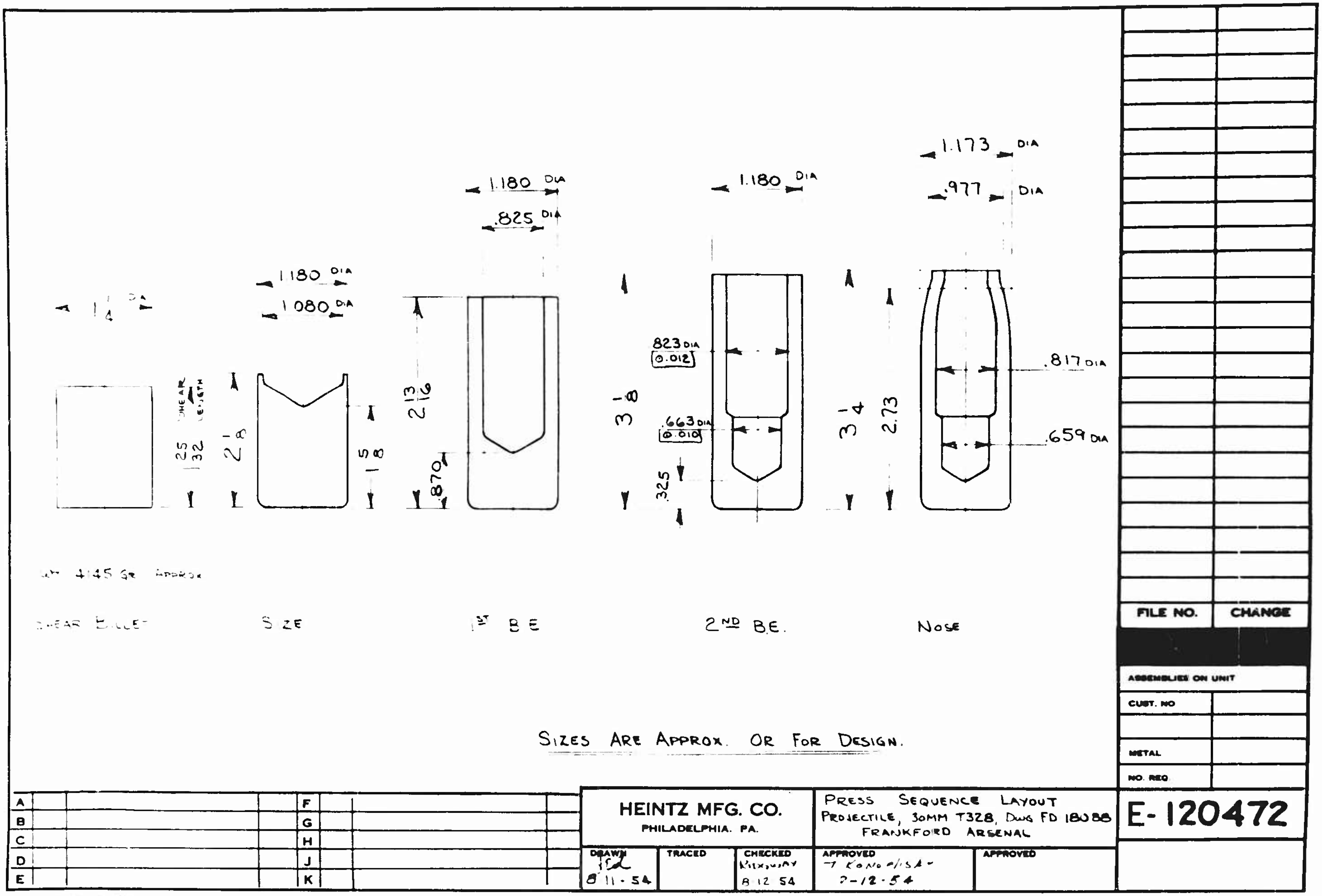
5. Surface treat
6. Size
7. Surface treat
8. Pre-backward extrude
9. Surface treat
10. First backward extrude
11. Surface treat
12. Second backward extrude
13. Nose
14. Stress relieve

In reaching the decisions outlined above a preliminary sequence of operations was prepared. When the thinking had crystallized and the volumetric relationships were calculated, a final drawing of the sequence of operations was made. This drawing #120472 is shown on the page immediately following this text.

The tooling required to extrude these pieces, and the gages necessary to measure them were then designed and built.

As the tools were tried out, and pieces made, there was considerable metallurgical experimentation to determine the optimum thermal treatment for both the process anneal and the final stress relief anneal.

These operations will now be discussed in detail with regard for practical considerations of a mechanical, metallurgical and productive nature.


1 1/4 DIA
WT .4145 GR APPROX
SHEAR BILLET
1 25/32 SHEAR LENGTH
1.180 DIA
1.080 DIA
2 1/8
1 5/8
SIZE
1.180 DIA
.825 DIA
2 13/16
.870
1ST B E
1.180 DIA
3 1/8
823 DIA
0.012
.663 DIA
0.010
.325
2ND B.E.
1.173 DIA
.977 DIA
3 1/4
2.73
.817 DIA
.659 DIA
NOSE
SIZES ARE APPROX. OR FOR DESIGN.
A
B
C
D
E
F
G
H
J
K
HEINTZ MFG. CO.
PHILADELPHIA. PA.
PRESS SEQUENCE LAYOUT
PROJECTILE, 30MM T328, DWG FD 18088
FRANKFORD ARSENAL
E-120472
DRAWN
8-11-54
TRACED
CHECKED
8 12 54
APPROVED
7-12-54
APPROVED
FILE NO.
CHANGE
ASSEMBLIES ON UNIT
CUST. NO
METAL
NO. REQ
J. H. WEIL & CO PHILA

PROJECTILE, TARGET PRACTICE, 30MM, T328

COLD FORMING OPERATIONS

1. SHEAR BILLETS

The tooling required to shear the 1-1/4" diameter hot rolled bar is shown on Dwg #114782 which immediately follows the text on shell T241 and T304.

Random length bars were hand fed into the die during the up stroke of the press, and the billets were sheared to the proper weight of 4, 145 grains and fell out below the die.

With the exception of a tendency for galled metal to build up on the stop block, this operation was performed with little difficulty.

The die was set in a 100 ton crank press built by Verson Allsteel Press Company, although only 43 tons were actually required.

2. TUMBLE BILLETS

This operation removed the sharp edges and burrs from the face of the billet.

To chamfer the distorted slug by mechanical means would have been difficult, and hand deburring was economically prohibitive. Tumbling offered an ideal solution to this problem in that it accomplished the objectives and required only a part-time operator to load and unload about one thousand (1, 000) pieces every forty-five (45) minutes.

3. ANNEAL BILLETS

Billets were heated in an electric furnace manufactured by The Lindberg Engineering Company to a temperature of 1250° F., soaked at this temperature for one and one-half (1-1/2) hours and air cooled.

A high but yet subcritical anneal such as this restored the original ductility to the sheared face of the billet without disturbing the structure of the steel. This thermal treatment also minimized the piece-to-piece differences in hardness which increased the repetitive accuracy of the forming operations.

4. SHOTBLAST

The pieces, which were annealed in the presence of oxygen, scaled rather heavily. The best method of removing such a surface was mechanical blasting. This resulted in a surface which was clean and bright and which could be surface treated using the same chemical cycle employed to coat intermediate process pieces.

The pieces were placed in a gravity conveyor which fed them into the machine, where they were blasted and ejected automatically.

The wheelabrator used for this operation was the American Wheelabrator Corporation's tumble blast machine. When blasting annealed billets such as these it was important to use soft shot to prevent any imbedding of the shot in the relatively soft billets.

5. SURFACE TREAT BILLETS

This surface treatment, or "Foscoating", operation was done on the Heintz experimental, manual Foscoat line. The pieces were placed in stainless steel trays by an operator and then the baskets were carried through the chemical cycle which follows:

1. Alkaline clean
2. Cold water rinse
3. Sulphuric acid pickle
4. Cold, overflowing water rinse
5. Hot, overflowing water rinse
6. Foscoat
7. Cold, overflowing water rinse
8. Hot, overflowing water rinse
9. Lubrication

Chemicals were supplied by Pennsylvania Salt Manufacturing Company of Philadelphia.

A complete description of the chemical constituents and process controls is contained in the appendix section entitled "Chemical Data".

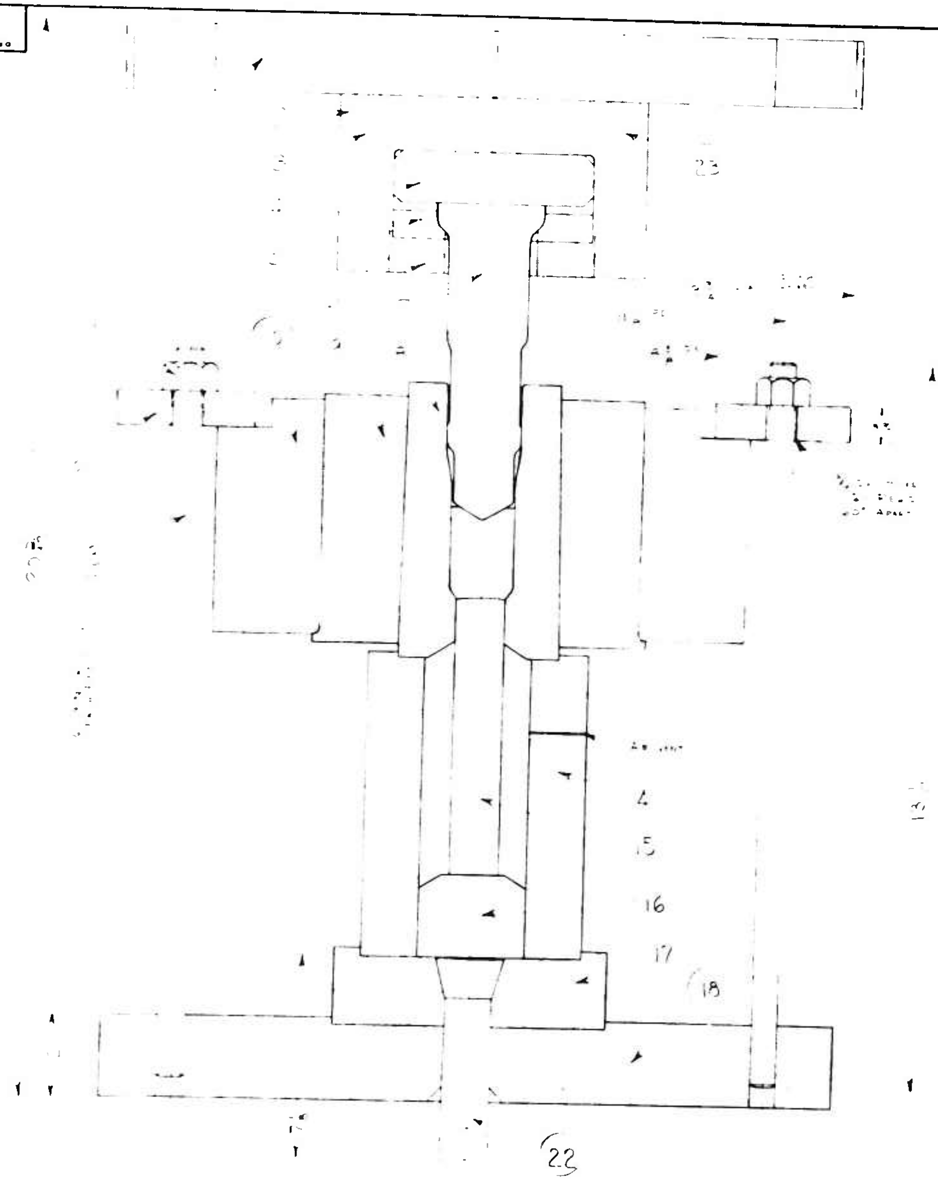
6. <u>SIZE BILLET</u>

The tooling necessary to form this piece is shown on Dwg #B-119824 which immediately follows this text.

The Foscoated sheared slug was placed in the die and formed as shown on the above listed drawing. Great care had to be taken to properly align this die, as the impression made by the punch served as a guide for the backward extrusion punches which followed. If the die were misaligned, the piece would have been unalterably eccentric.

The shut height of the die had to be regulated to make the piece of the required size.

This die was run on a Verson 100 ton single point mechanical press. The required force for this operation was 118 tons.



BILL OF MATERIALS

[illegible]	[illegible]	[illegible]	[illegible]

NOTE—

1. Punch & Bench Assem. is not shown here. See Detail Dwg. - B 114785 &
2. Finish Size

HEINTZ MFG. CO.
PHILADELPHIA, PA.

Size Die
30MM. T328 - FD 6088
Frankford Arsenal

Cust. No. 58 03

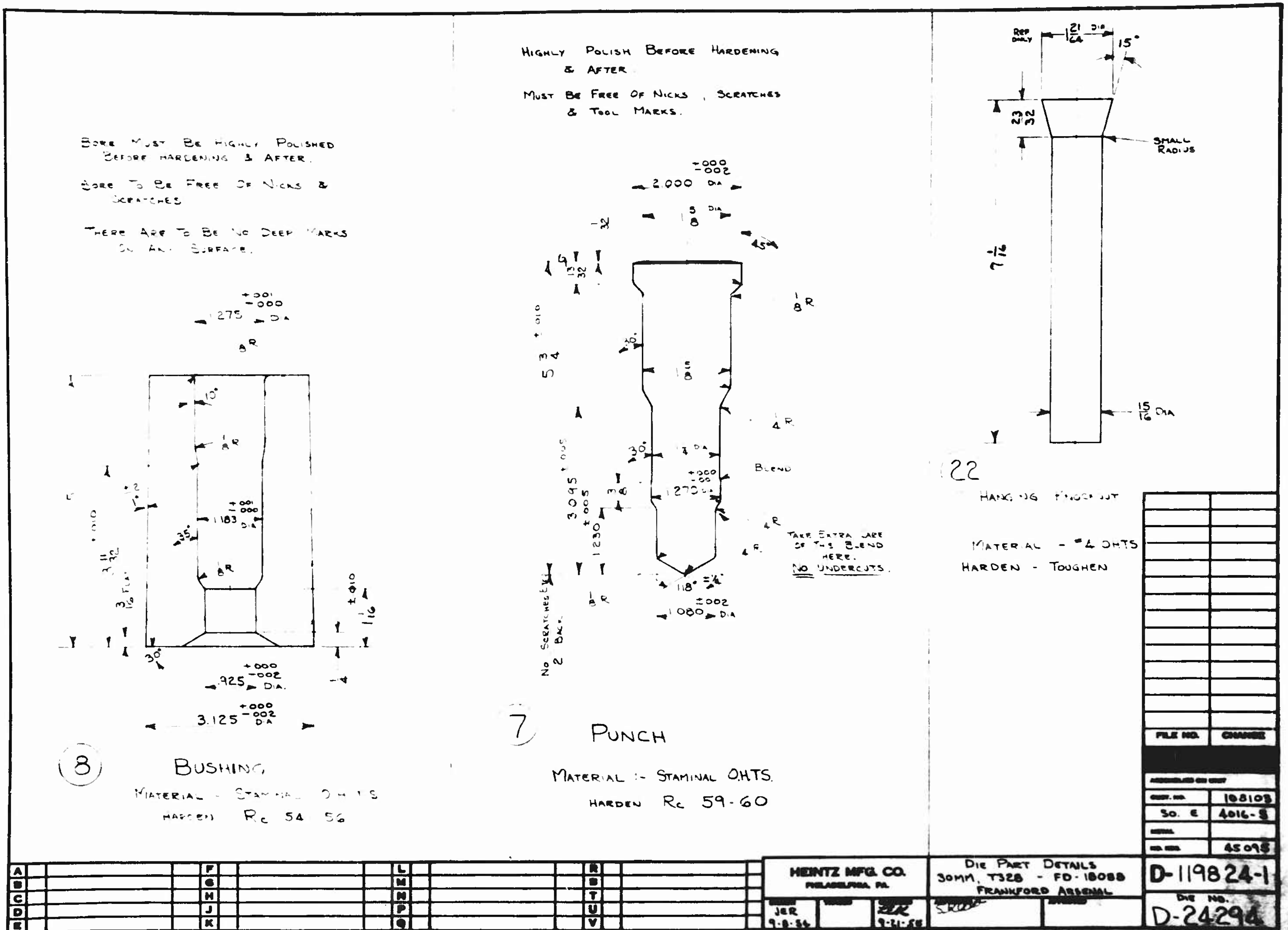
40-6-5

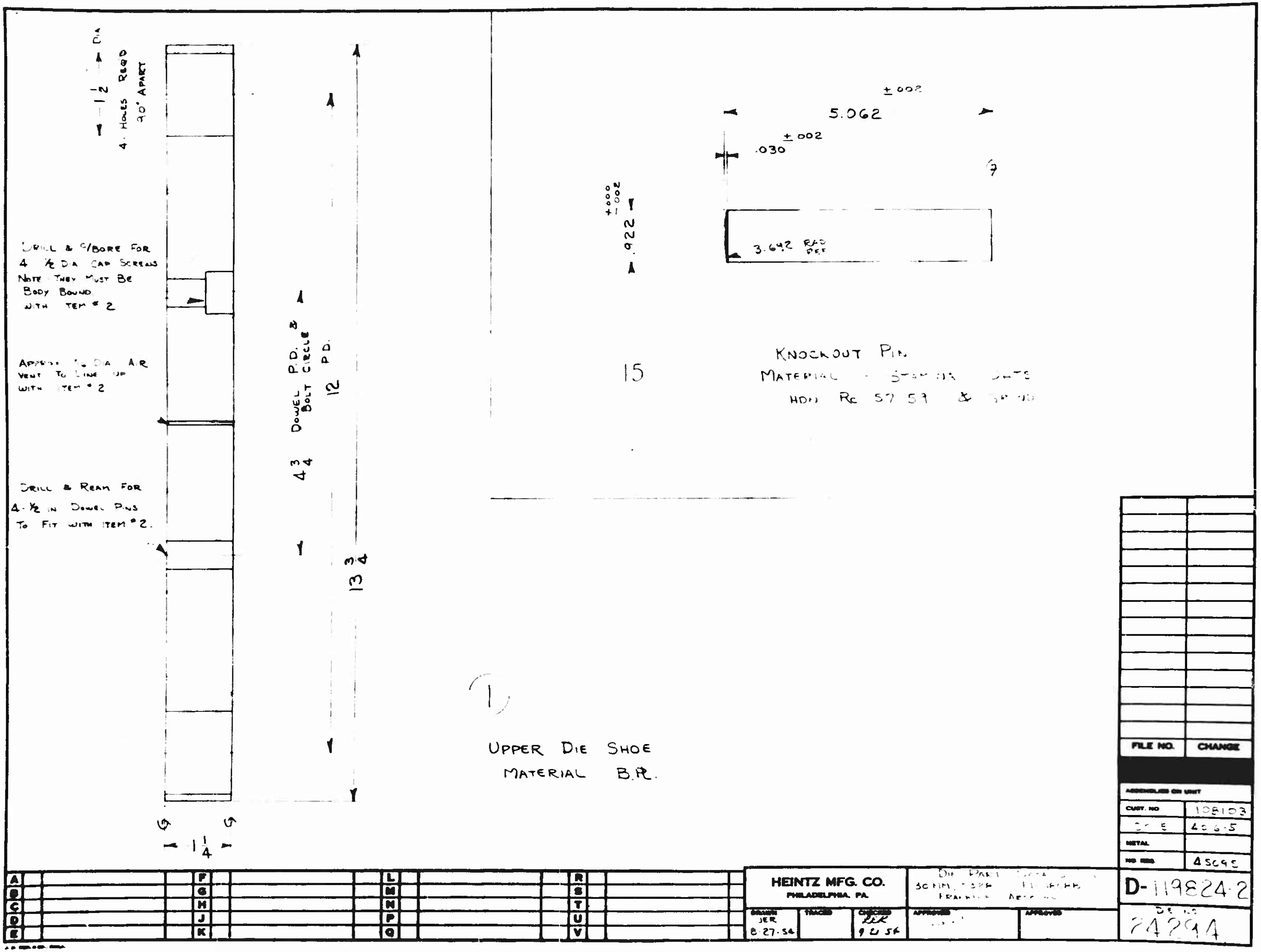
45695

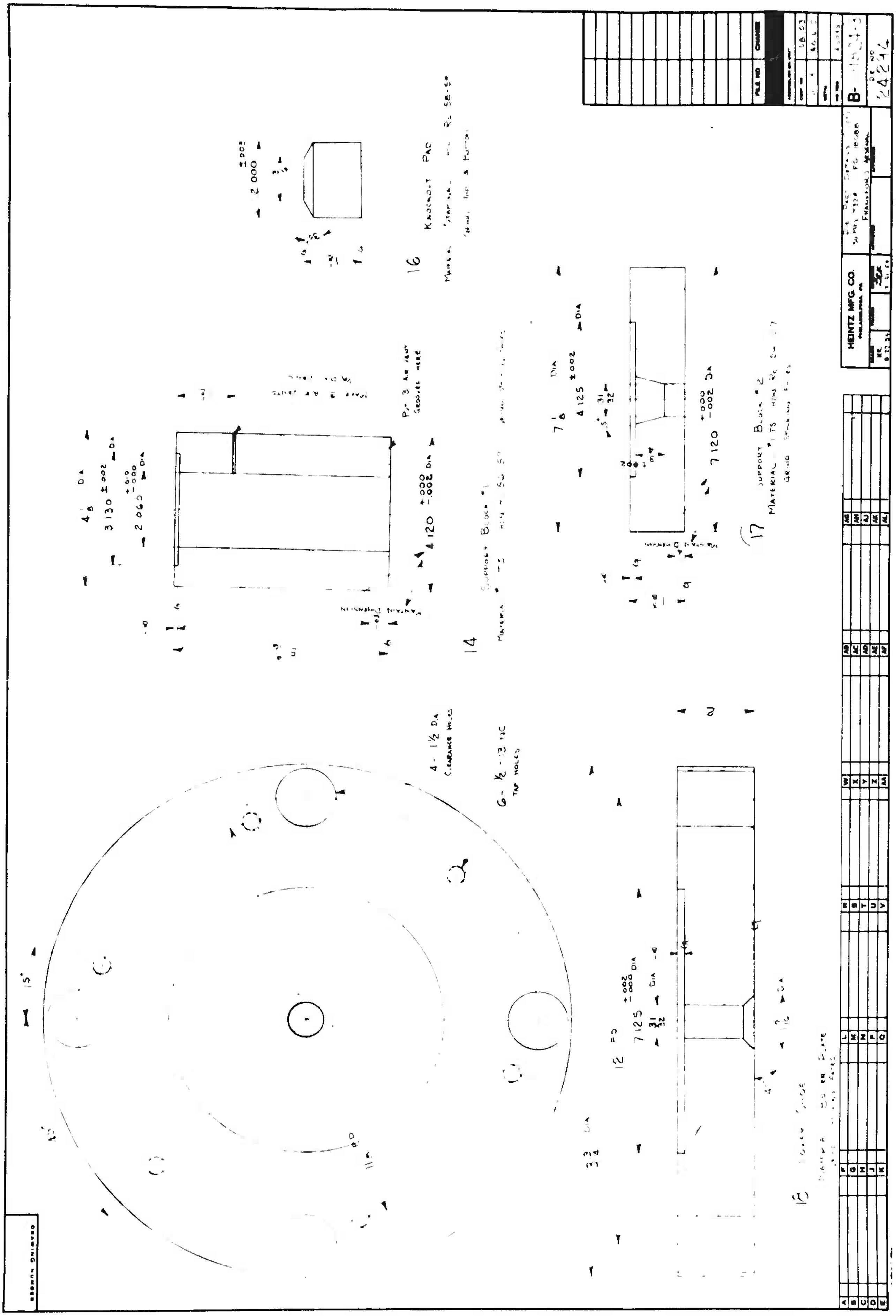
B-19824

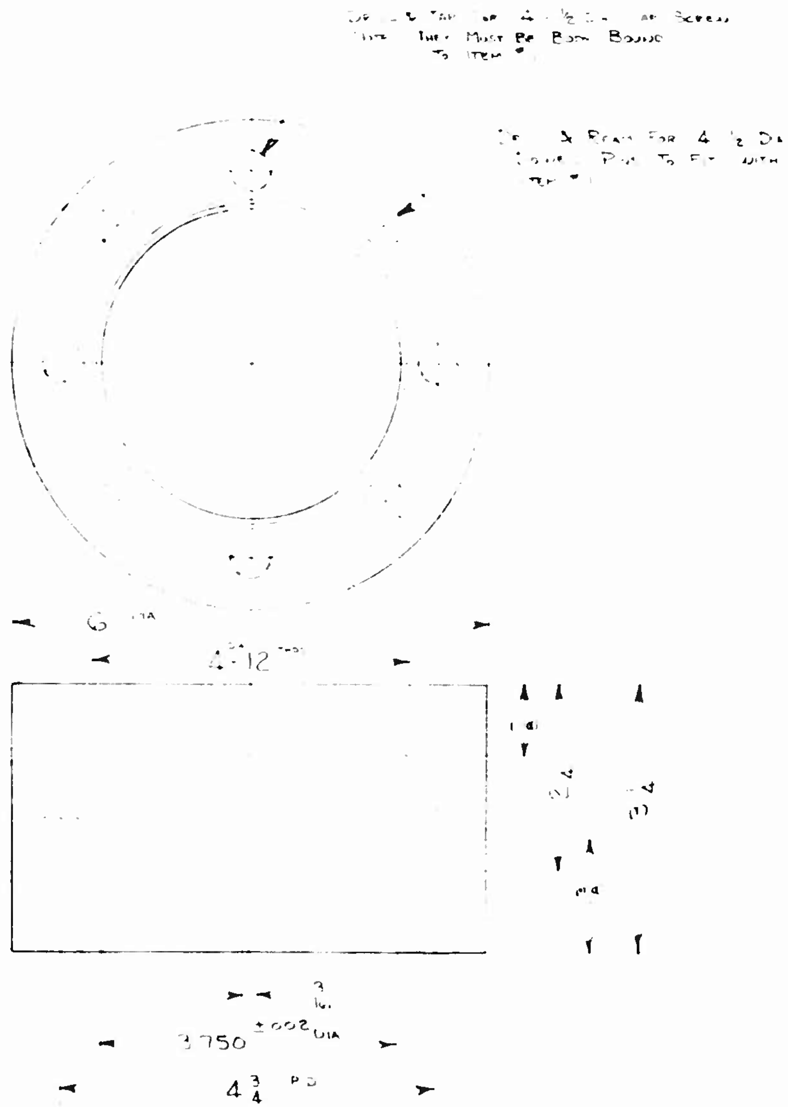
D-24294

FILE NO. | CHANGE


HIGHLY POLISH BEFORE HARDENING & AFTER
MUST BE FREE OF NICKS, SCRATCHES & TOOL MARKS.
BORE MUST BE HIGHLY POLISHED BEFORE HARDENING & AFTER.
BORE TO BE FREE OF NICKS & SCRATCHES
THERE ARE TO BE NO DEEP MARKS ON ANY SURFACE.
TAKE EXTRA CARE OF THIS BLEND HERE. NO UNDERCUTS.
BLEND
NO SCRATCHES EXC. 2 BACK
8
BUSHING
MATERIAL - STAMINAL O.H.T.S.
HARDEN Rc 54 56
7
PUNCH
MATERIAL :- STAMINAL O.H.T.S.
HARDEN Rc 59-60
22
HANGING KNOCKOUT
MATERIAL - #4 O.H.T.S
HARDEN - TOUGHEN
SMALL RADIUS
REF ONLY
FILE NO.
CHANGE
108103
SO. E
4016-S
45095
HEINTZ MFG. CO.
PHILADELPHIA, PA.
DIE PART DETAILS
30MM. T328 - FD-18088
FRANKFORD ARSENAL
JER
9-8-56
9-21-56
D-119824-1
DIE NO.
D-24294


4 - Holes Reqd 90° Apart
1/2 Dia
Drill & C/Bore For 4 - 1/2 Dia Cap Screws
Note They Must Be Body Bound With Item # 2
Approx 1/2 Dia Air Vent To Line Up With Item # 2
Drill & Ream For 4 - 1/2 in Dowel Pins To Fit With Item # 2.
1 1/4
4 3/4 Dowel P.D. & Bolt Circle
12 P.D.
13 3/4
Upper Die Shoe
Material B.R.
1
.922 +.000 -.002
15
5.062 ±.002
.030 ±.002
3.642 Rad Ref
Knockout Pin
HEINTZ MFG. CO.
PHILADELPHIA, PA.
FILE NO.
CHANGE
ASSEMBLED ON UNIT
CUST. NO
108103
METAL
4595
D-119824-2
24294
DRAWN JER 8-27-54
TRACED
CHECKED
APPROVED


HEINTZ MFG. CO.
PHILADELPHIA PA
KNOCKOUT PAD
SUPPORT BLOCK #1
SUPPORT BLOCK #2
4 - 1½ DIA
CLEARANCE HOLES
6 - ½ - 13 NC
TAP HOLES
FILE NO
CHANGE
B-



2) PUNCH RETAINER

MATERIAL

A		F		L		R	
B		G		M		S	
C		H		N		T	
D		J		P		U	
E		K		Q		V	

HEINTZ MFG. CO.
PHILADELPHIA, PA.

DIE PARTS DETAILS
FRANKFORD ARSENAL

DRAWN	TRACED	CHECKED	APPROVED	APPROVED
ER 9-7-54		LEK 9-11-54		

FILE NO.	CHANGE

ASSEMBLIES ON UNIT

CUST. NO.	108103
S.O. E	4016-5
METAL	
NO. REQ.	45095

D-119824-4

DIE NO. 24294

7. SURFACE TREAT

This operation was identical to Operation #5.

8. PRE-BACKWARD EXTRUDE

This piece was formed in the tooling originally designed for the first backward extrusion. As previously explained, this extrusion was added to the sequence to compensate for the inability of the coating to withstand such deep punch penetration.

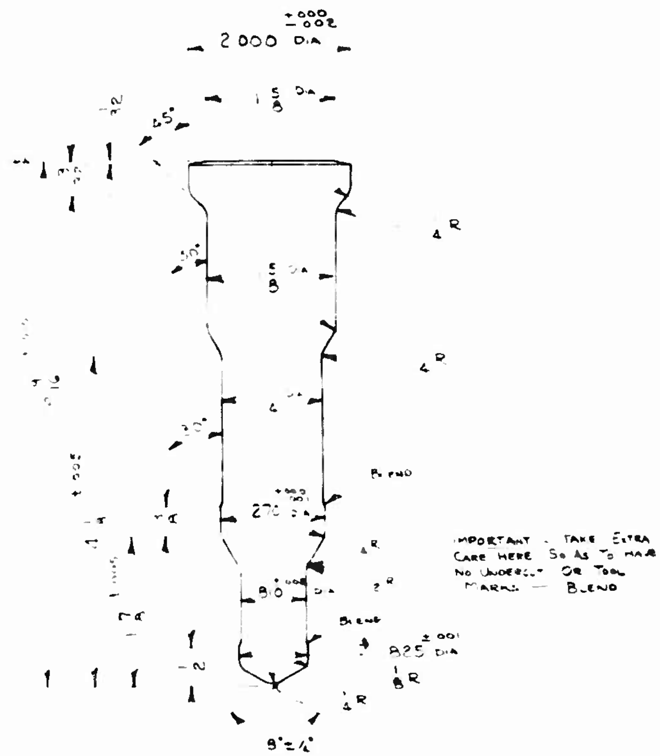
The alignment of this die was very important, in that it determined to a large extent the concentricity of the shell. The press shut height setting was not so critical as is generally true, since this operation was followed by first backward extrusion which finally formed the .820" diameter.

The tools are shown on Dwg #D-119825-4 which immediately follows the text describing the first backward extrusion. This operation differs from first backward extrusion only in the setting of press shut height.

The die was run on a Verson 100 ton single point mechanical press. The load required to form this piece was 78 tons.

HIGHLY POLISH BEFORE HARDENING
& AFTER

MUST BE FREE OF NICKS SCRATCHES
& TOOL MARKS



24 PRE-BE PUNCH

MATERIAL – R D S

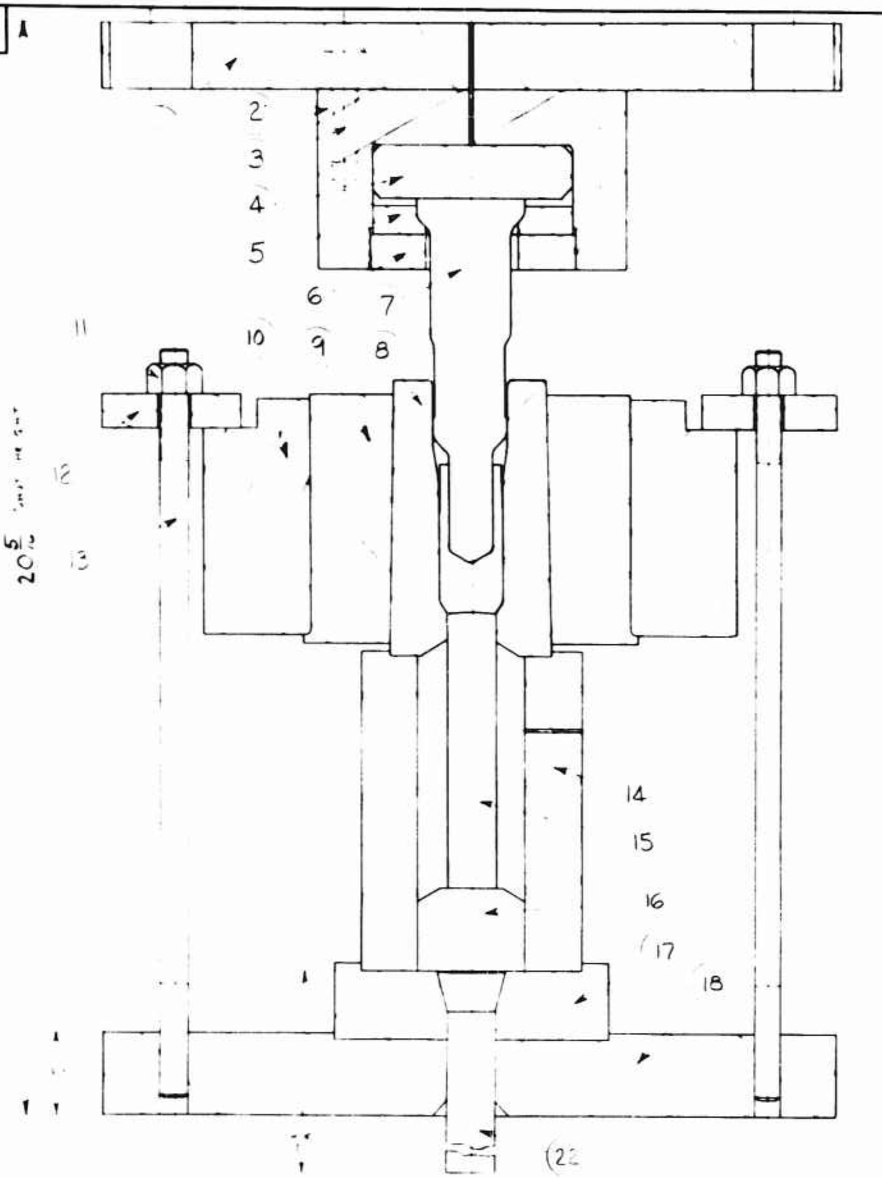
HARDEN – Rc 59–60

HEINTZ MFG. CO. PHILADELPHIA PA.	DIE PART DETAILS (PRE-B.E.) 30 MM, T328 – FD-18088 FRANKFORD ARSENAL
JER 4-25-55	JCR 4-25-55
T. [illegible] 4-25-55	

CUST. NO.	108103
S.O. E	4016-25
	47383

D-119825-4

DIE NO. 24295



NOTE:-

1. Parts Item No. 2 3 4 5 ... 2 3 - 16 17 18 19 20 21 ... -23 Are **NOT** To Be Made For This Die

2. Use Similar Parts From Die # 24294 Dwg. # ...1824

3. Finish Size

HEINTZ MFG. CO. PHILADELPHIA, PA	First Backward Extrusion Die 30 mm. T328 FD 18088 Frankford Arsenal
108103	4016 6
50 E	45096
B-119825	D-24295

9. SURFACE TREAT

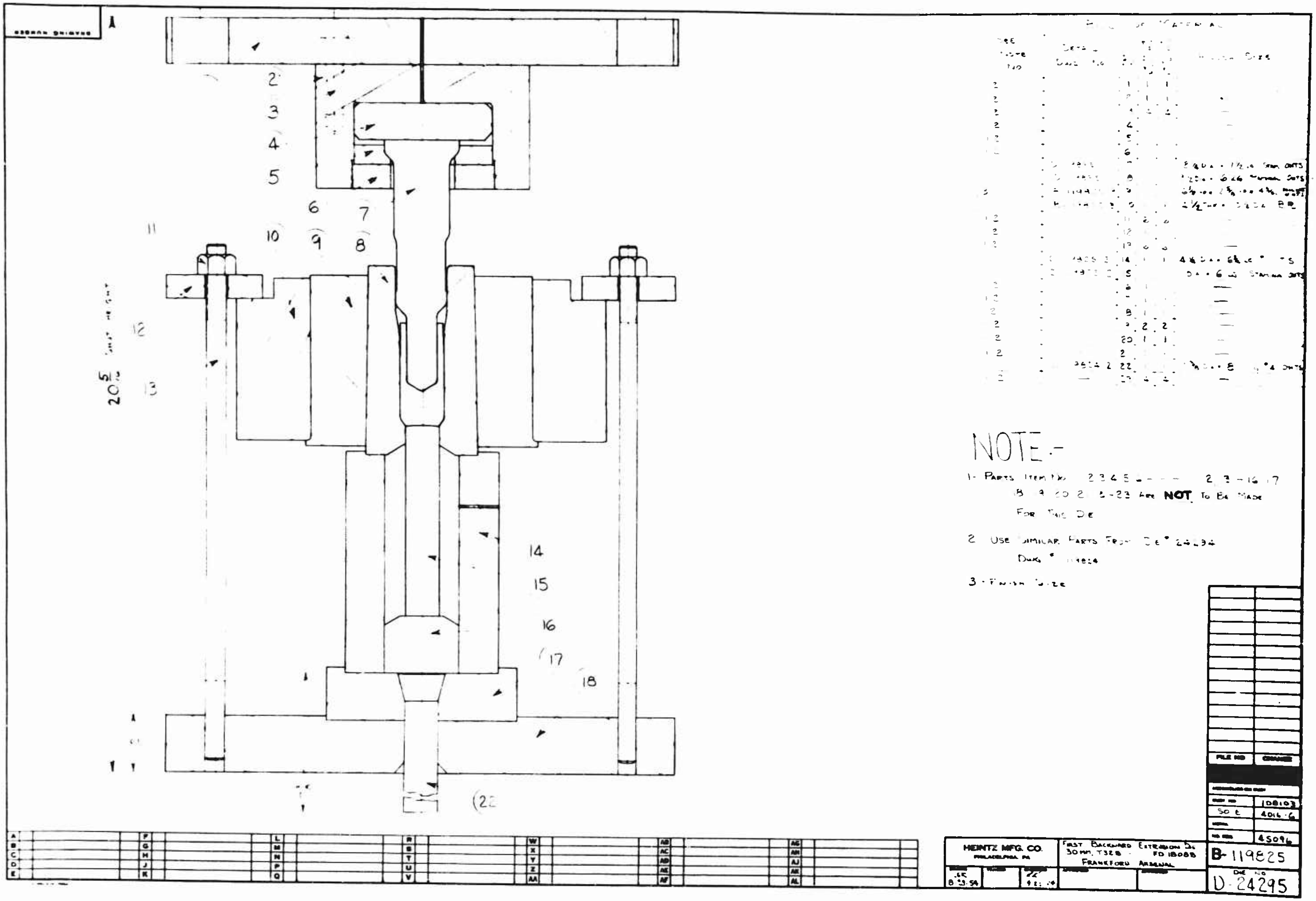
This operation was the same as operation #5 with the exception that a mechanical method of oscillating the pieces was used to allow the air to escape from the cavity.

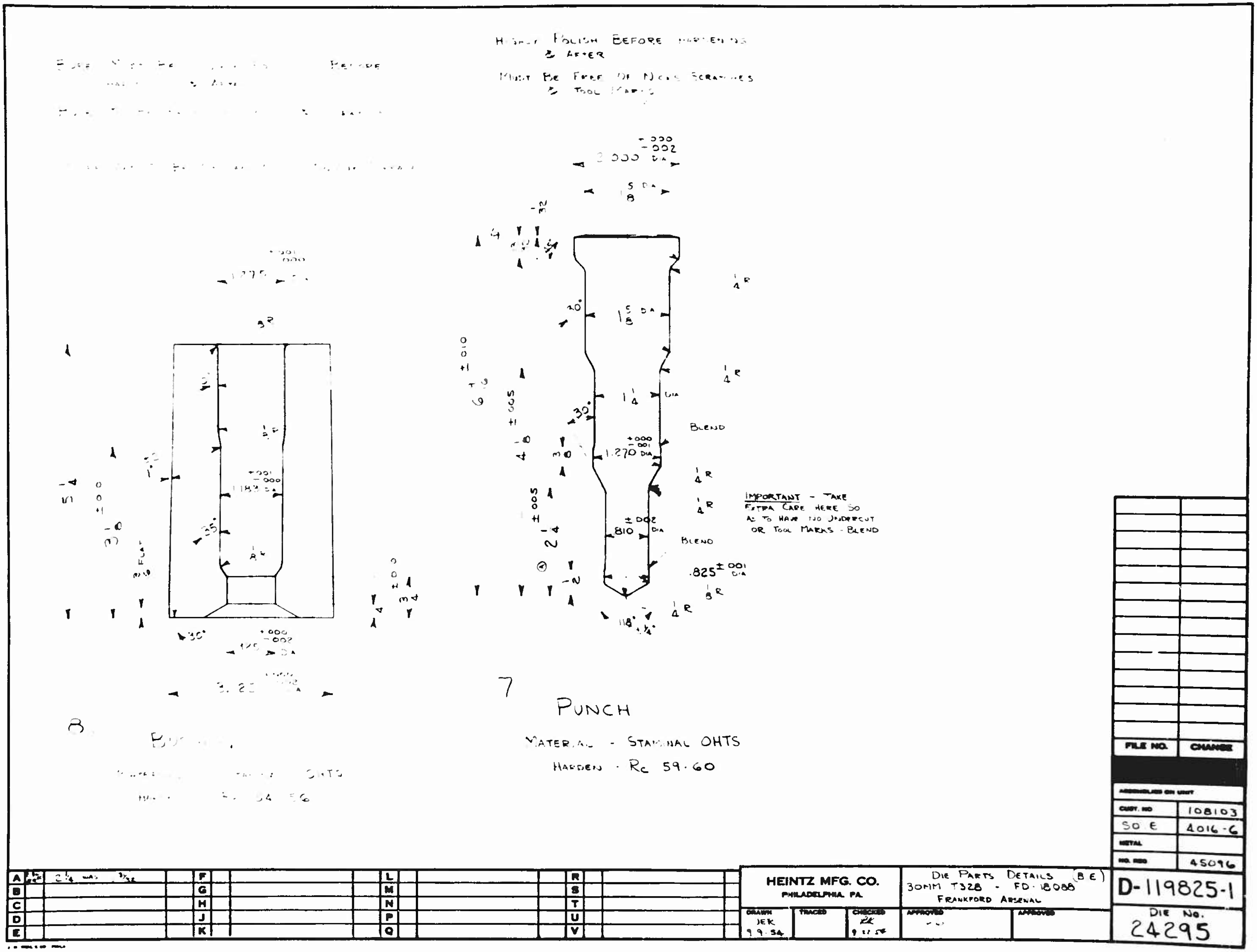
10. <u>FIRST BACKWARD EXTRUDE</u>

In this operation, as in all backward extrusions, the metal was stressed until it flowed up through the annular opening between punch and die.

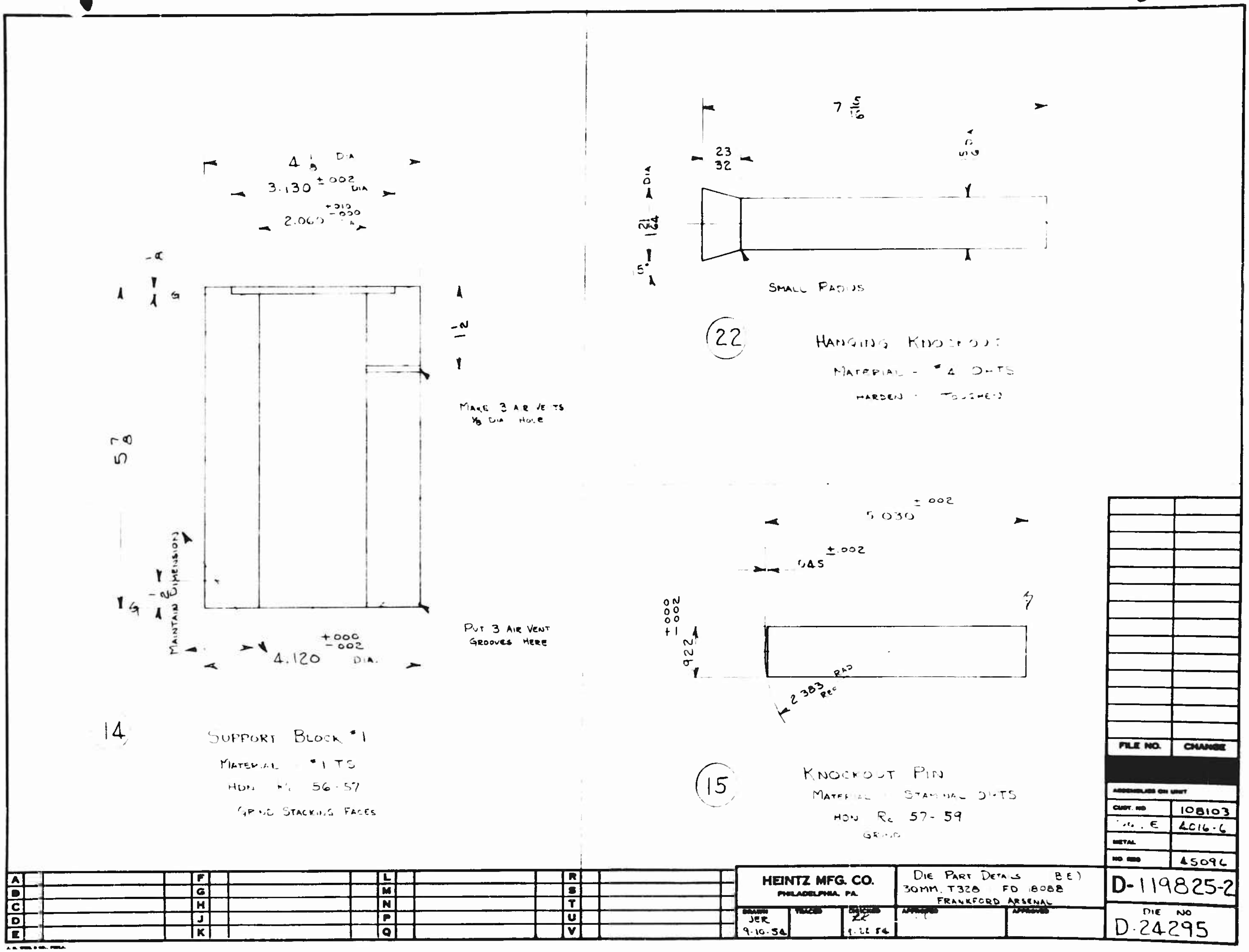
The press shut heights had to be adjusted to make a piece with the desired base thickness of .870" plus or minus .005". The die had to be carefully aligned, and the piece, when made, had to be checked to see that the eccentricity did not exceed .010" TIR.

The tooling was set in a 100 ton Verson single point mechanical press and a force of 78 tons was necessary to extrude the metal. The tooling is described on Dwg #B-119825 which follows this text.


NOTE:-
1- Parts Item No. 2 3 4 5 ... 2 3 - 16 17 18 19 20 2 3-23 Are NOT To Be Made For This Die
2 Use Similar Parts From Die # 24294
3 - Finish Size
HEINTZ MFG. CO.
PHILADELPHIA PA
First Backward Extrusion Die
30 MM. T328 FD 18088
Frankford Arsenal
B-119825
D-24295
45096



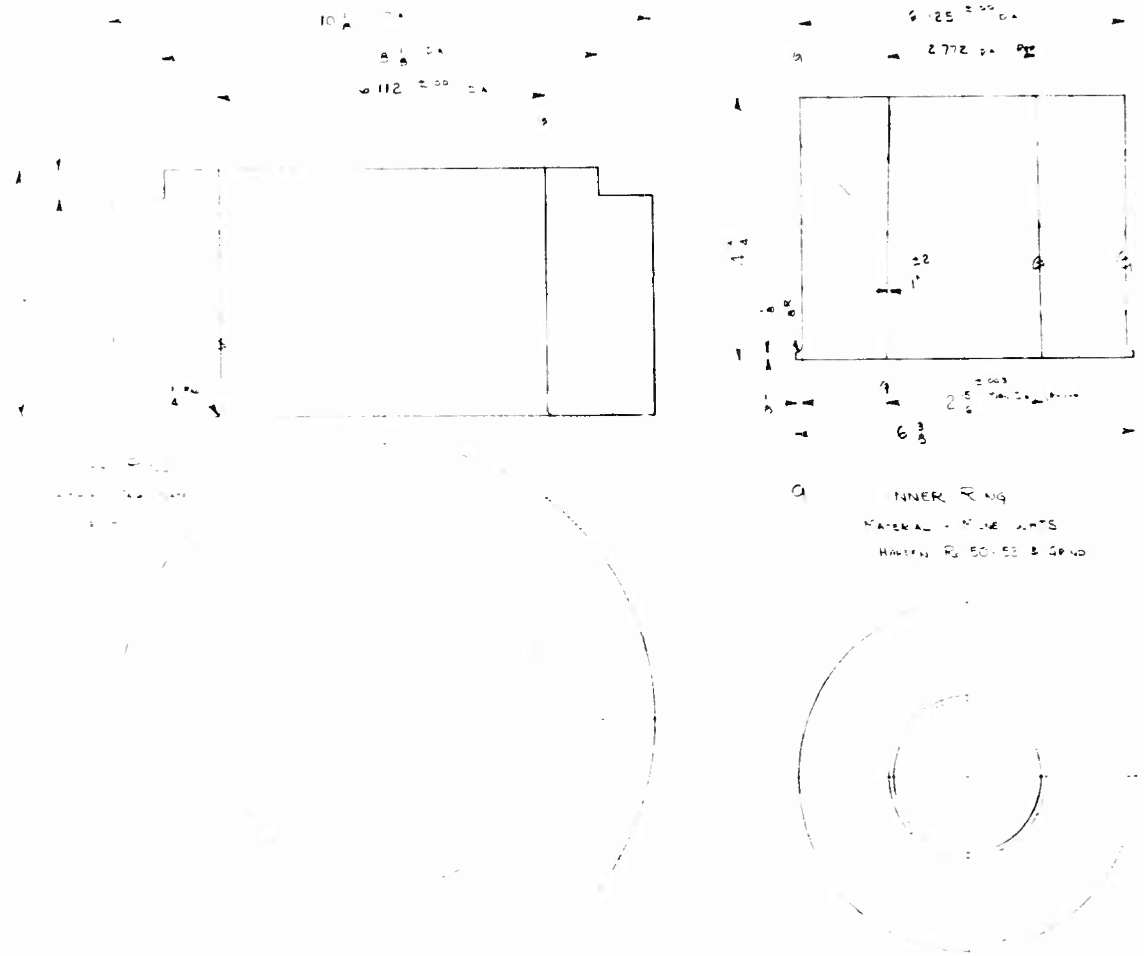
HIGHLY POLISH BEFORE HARDENING & AFTER
MUST BE FREE OF NICKS SCRATCHES & TOOL MARKS
IMPORTANT - TAKE EXTRA CARE HERE SO AS TO HAVE NO UNDERCUT OR TOOL MARKS - BLEND
BLEND
7
PUNCH
MATERIAL - STAMINAL OHTS
HARDEN - Rc 59-60
8
HEINTZ MFG. CO.
PHILADELPHIA PA.
DIE PARTS DETAILS (B E)
30MM T328 - FD 18088
FRANKFORD ARSENAL
DRAWN JEK 9-9-54
FILE NO.
CHANGE
CUST. NO 108103
SO E 4016-6
NO. REQ 45096
D-119825-1
DIE No. 24295

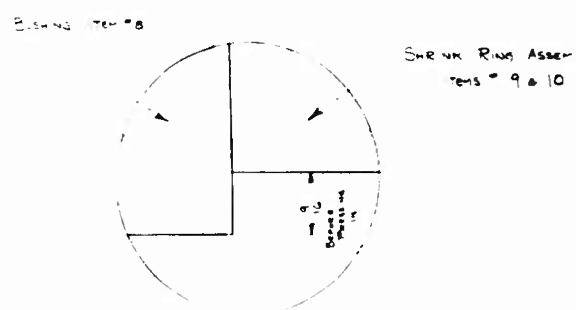


4 1/8 DIA
3.130 ± .002 DIA
2.060 +.010 −.000
5 7/8
MAINTAIN DIMENSION
4.120 +.000 −.002 DIA.
MAKE 3 AIR VENTS 1/8 DIA HOLE
PUT 3 AIR VENT GROOVES HERE
14
SUPPORT BLOCK #1
MATERIAL #1 TS
HDN 56-57
GRIND STACKING FACES
7 5/16
23/32
DIA
21/64
5°
SMALL RADIUS
22
HANGING KNOCKOUT
MATERIAL #4 DHTS
5.030 ± .002
.045 ± .002
.922 +.000 −.002
2.383 REC RAD
15
KNOCKOUT PIN
MATERIAL STANDARD DHTS
HDN Rc 57-59
GRIND
FILE NO.
CHANGE
CUST. NO 108103
4016-6
45096
HEINTZ MFG. CO.
PHILADELPHIA, PA.
DIE PART DETAILS (BE)
30MM. T328 FD 18088
FRANKFORD ARSENAL
DRAWN JER 9-10-54
D-119825-2
DIE NO D-24295

General Directions For Making Shrink Rings -

1- Outer Ring To Be Turned To Size
2 Inner Ring
  A Turn Allow For Grinding Bore & OD
  B - Heat Treat Harden Rc 50 52
  C - Grind OD To Size
3 Heat Outer Ring To Approx 700°F
4 Insert Inner Ring
5 No Eyebolt Holes Allowed In Either Piece
6 - Grind Bore Of Assembly To Fit Inner Bushing Per Sketch Below
7 Stamp On Outer Ring Die No & Assem Dwg No





Mach Dwg No

HEINTZ MFG. CO.	Die Part Details (B E)
	30MM T328 - FD 10088
JER 9-16-54	

	108103
90 E	4014-6
	45096

B-119825-3

Die No D-24295

11. <u>SURFACE TREAT</u>

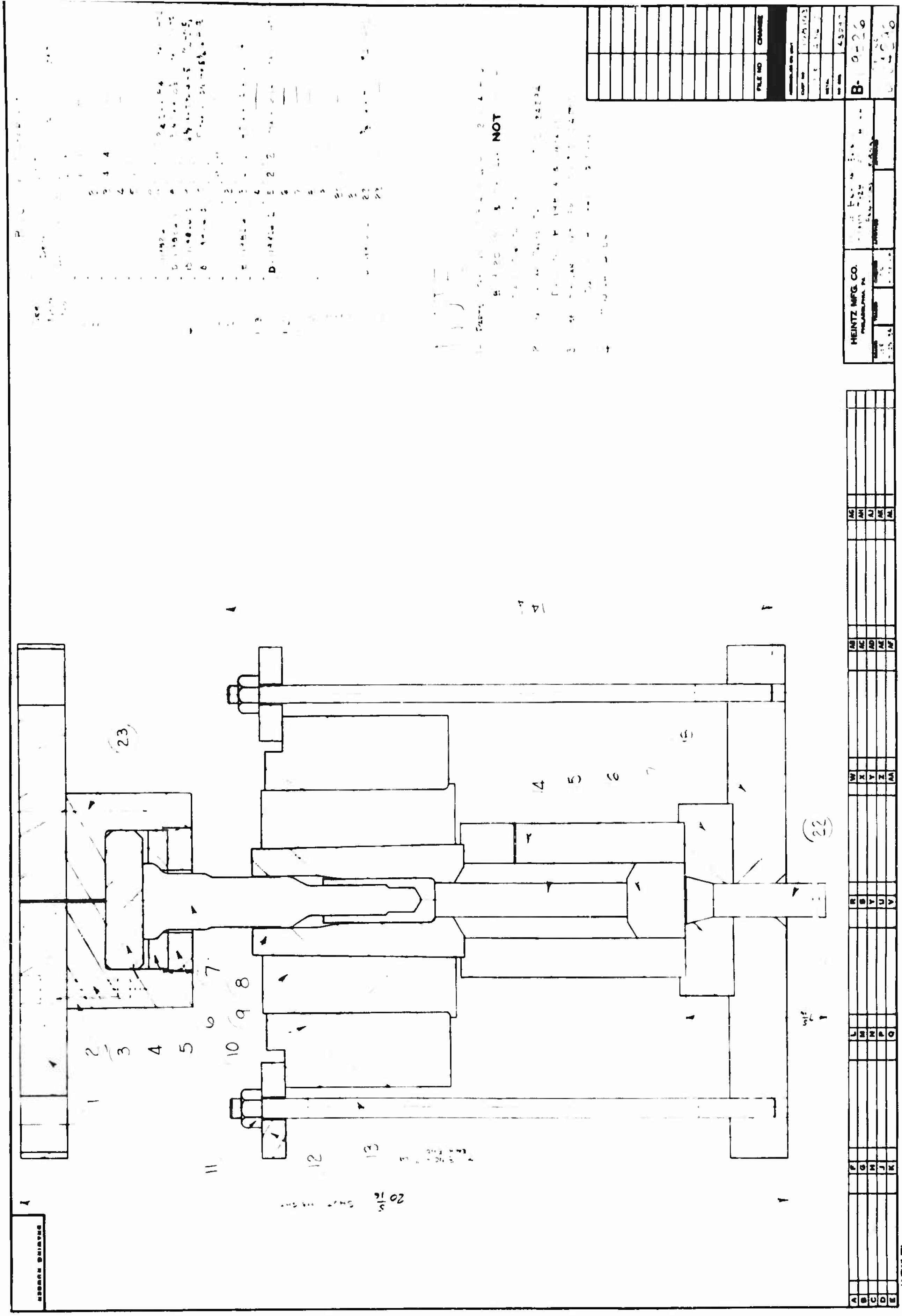
This surface treating procedure was identical to that described as operation #5.

12. SECOND BACKWARD EXTRUDE

The .663" inside diameter was formed by this extrusion using the tooling shown on Dwg #B-119826 which immediately follows.

The Foscoated first backward extruded piece was placed in the die and forced down by the punch which then stressed the metal causing it to flow upward around the punch. The press setting was adjusted to give the proper bottom thickness of .322 to .328. The alignment of the die had to be consistent with an eccentricity requirement of .010" TIR. Enough metal was extruded in this die so that it flowed up and around the shoulder on the punch allowing the location of the inside shoulder of the piece to be positioned with great accuracy.

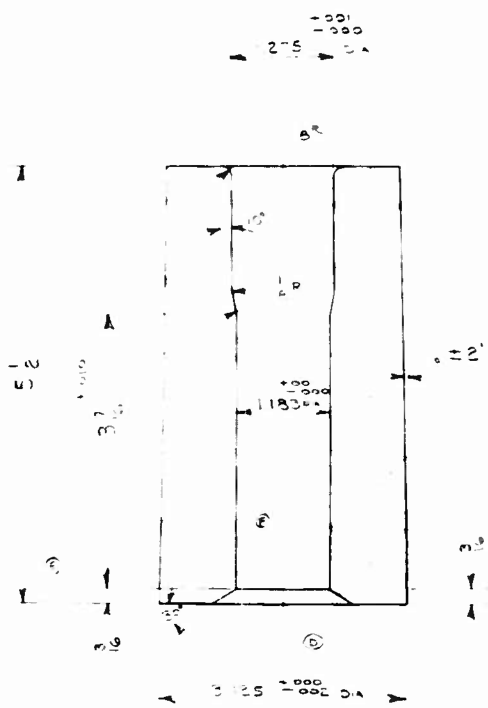
The die was set in a 100 ton Verson single point mechanical press. This extrusion actually required only 79 tons.


HEINTZ MFG. CO.
NOT

Bore Must Be Highly Polished Before Hardening & After

Bore To Be Free Of Nicks & Scratches.

There Are To Be No Deep Marks On Any Surface



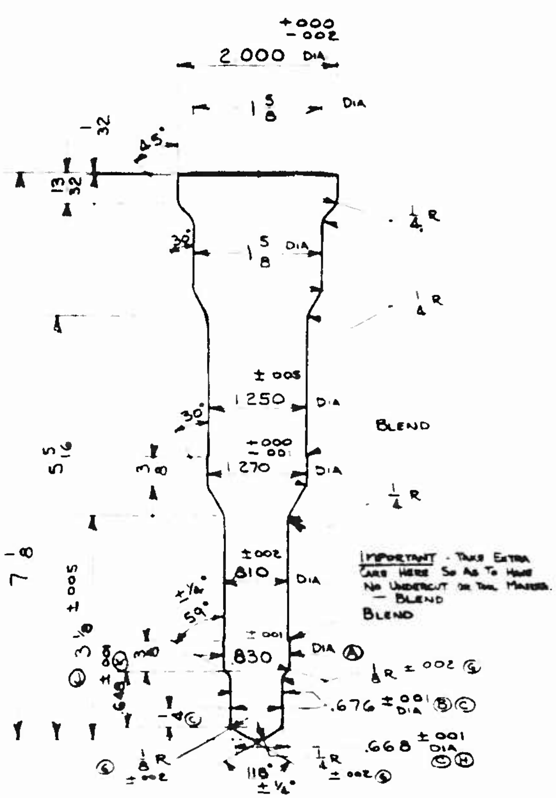
8 · Bushing

Material - Staminal OHTS

Harden Rc 54 56

Highly Polish Before Hardening & After.

Must Be Free Of Nicks, Scratches & Tool Marks



7 Punch

Material :- Staminal OHTS

Harden :- Rc 59 - 60

A	.830 WAS .823	F	WAS 1/8 ± RAD IN CORNER	L		R				
B	.676 WAS .663	G	ADDED TOLERANCE TO RADII	M		S				
C	ADDED TAPER	H	.668 WAS .660	N		T				
D	WAS .933 +.000 -.001 KA-ID	J	3 1/8 WAS 2.875	P		U				
E	WAS 1/8 FROM BOTTOM	K	.648 WAS .730	Q		V				

FILE NO.	CHANGE
CUST. NO.	108103
So E	4016-7
NO.	45097

HEINTZ MFG. CO.
PHILADELPHIA, PA.

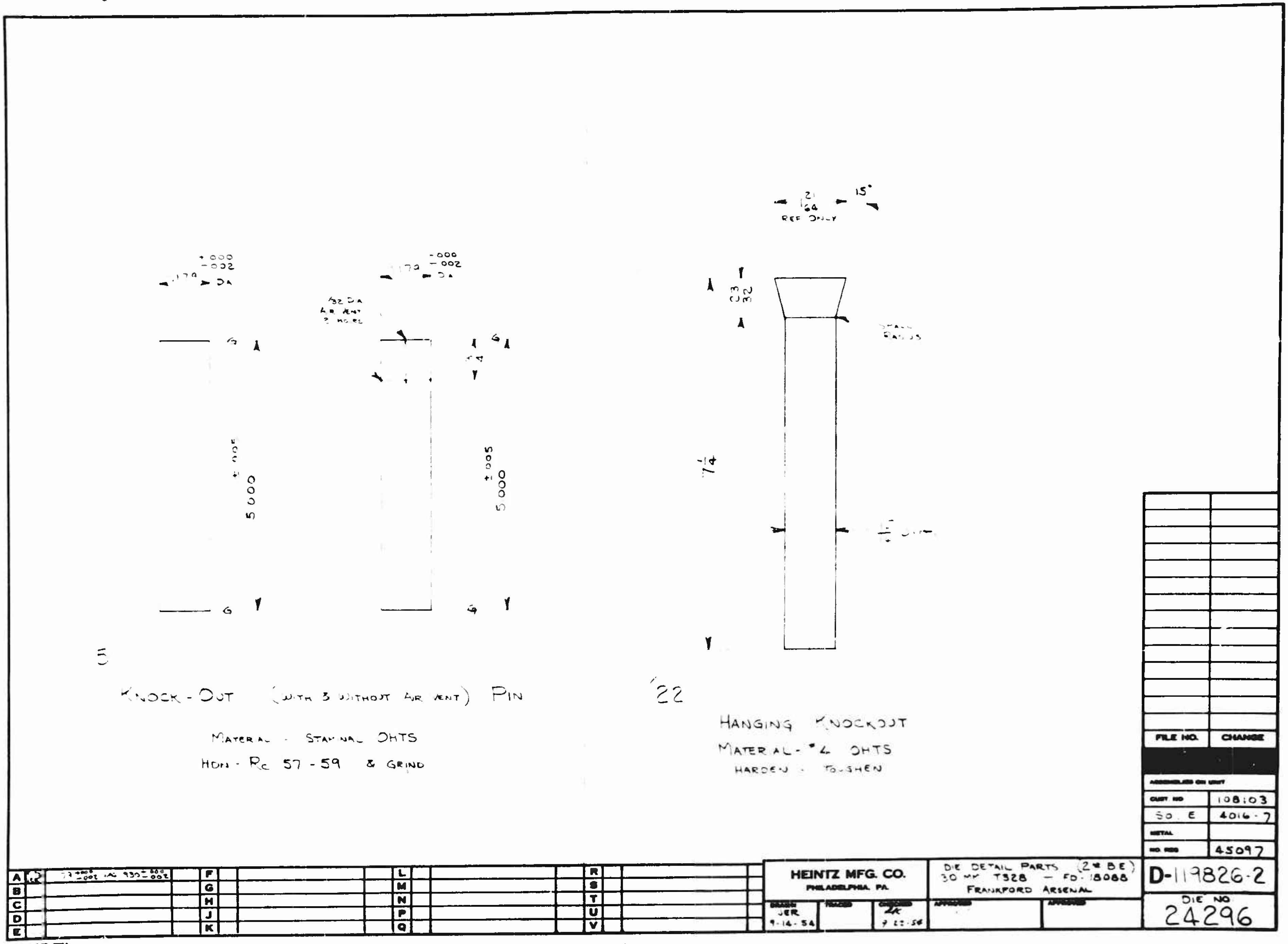
DIE PART DETAILS (2nd B.E.)
30 MM. T328 - FD-18088
FRANKFORD ARSENAL

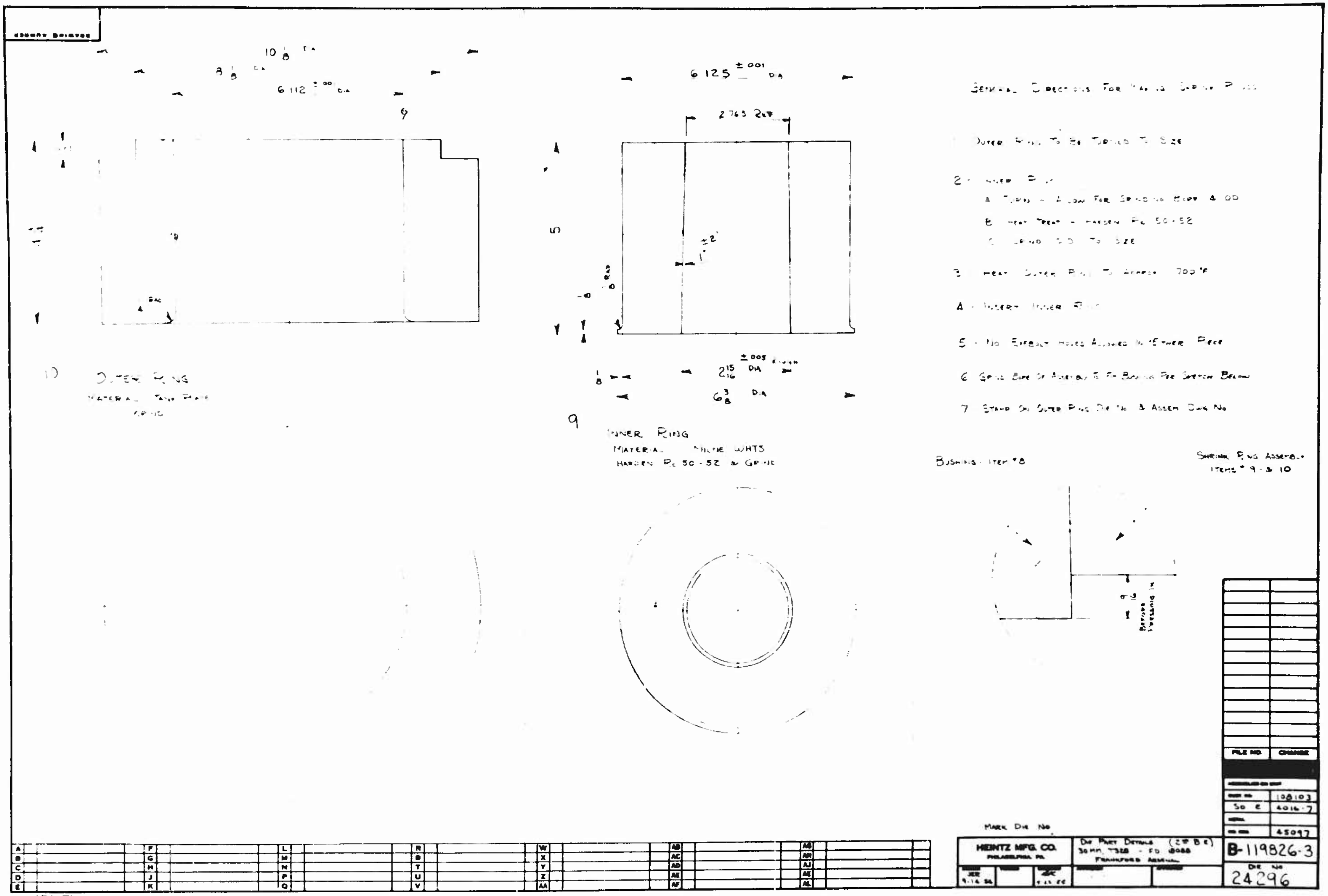
D-119826-1

DIE NO. 24296

JER 9-13-54

9-21-56


KNOCK-OUT (WITH & WITHOUT AIR VENT) PIN
MATERIAL - STAMINAL OHTS
HDN - Rc 57-59 & GRIND
5.000 ± .005
HANGING KNOCKOUT
MATERIAL - #4 OHTS
HARDEN - TOUGHEN
15°
21/64 REF ONLY
7 1/4
22
HEINTZ MFG. CO.
PHILADELPHIA, PA.
DIE DETAIL PARTS (2ND BE)
30 MM T328 — FD-18088
FRANKFORD ARSENAL
JER 9-14-54
D-119826-2
DIE NO. 24296
FILE NO.
CHANGE
108:03
SO. E 4016-7
45097


10 1/8 DIA
8 1/8 DIA
6 112 ± 00 DIA
Outer Ring
Material Tool Plate
Grind
6 125 ± 001 DIA
2 763 Ref
1° ± 2'
± 005
2 15/16 DIA
6 3/8 DIA
9
Inner Ring
Material Nilne WHTS
Harden Rc 50-52 & Grind
General Directions For Making Shrink Rings
1. Outer Ring To Be Turned To Size
2. Inner Ring
A Turn - Allow For Grinding Bore & OD
B Heat Treat - Harden Rc 50-52
C Grind OD To Size
3. Heat Outer Ring To Approx. 700 °F
4. Insert Inner Ring
5. No Eyebolt Holes Allowed In Either Piece
6. Grind Bore of Assembly To Fit Bushing See Sketch Below
7. Stamp On Outer Ring Die No & Assem Dwg No
Bushing - Item #8
Shrink Ring Assembly
Items # 9 & 10
Mark Die No
HEINTZ MFG. CO.
PHILADELPHIA PA
Die Part Details (2 Sh)
30 MM T328 - FD 8088
Frankford Arsenal
B-119826-3
Die No
24296
108103
50 E
4016-7
45097

13. NOSE

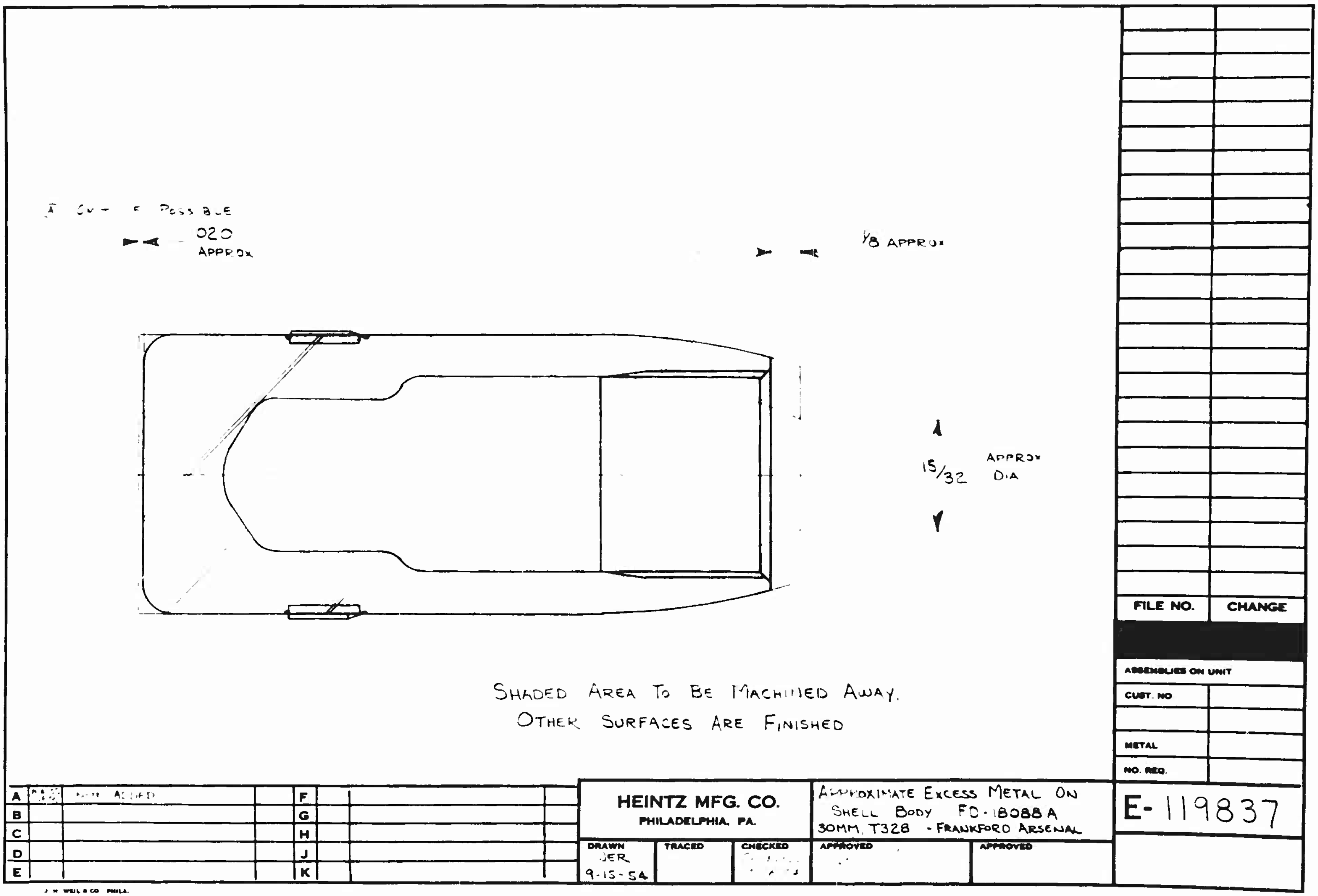
The tooling built to form this piece is illustrated on Dwg #B-119847 and is the same die as was used to nose the T306E10 shell body.

The piece was placed mouth down in the die nest and formed as it was pushed down into the contained die. The distance between the mouth diameter and the bottom of the shell was controlled within the range of 2.720 to 2.740". On the return stroke of the press the piece was ejected from the die by a knockout pin.

This tooling was run on a 100 ton Verson mechanical press although the operation required only 16 tons.

14. STRESS RELIEVE

The optimum stress relief temperature determined empirically was found to be 700° F. The pieces were held at this temperature for one and one-half (1-1/2) hours in a Lindberg Electric Furnace and air cooled. A discussion of the need for and the results obtained from this type of thermal treatment is found in the section entitled "Metallurgical Data and Discussion".


.020
APPROX
1/8 APPROX
15/32
APPROX
DIA
SHADED AREA TO BE MACHINED AWAY.
OTHER SURFACES ARE FINISHED
HEINTZ MFG. CO.
PHILADELPHIA, PA.
APPROXIMATE EXCESS METAL ON
SHELL BODY FD-18088 A
30MM. T328 - FRANKFORD ARSENAL
DRAWN
JER
9-15-54
TRACED
CHECKED
APPROVED
APPROVED
FILE NO.
CHANGE
ASSEMBLIES ON UNIT
CUST. NO
METAL
NO. REQ.
E-119837
A
B
C
D
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G
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K

PROJECTILE, TARGET PRACTICE, 30MM, T328

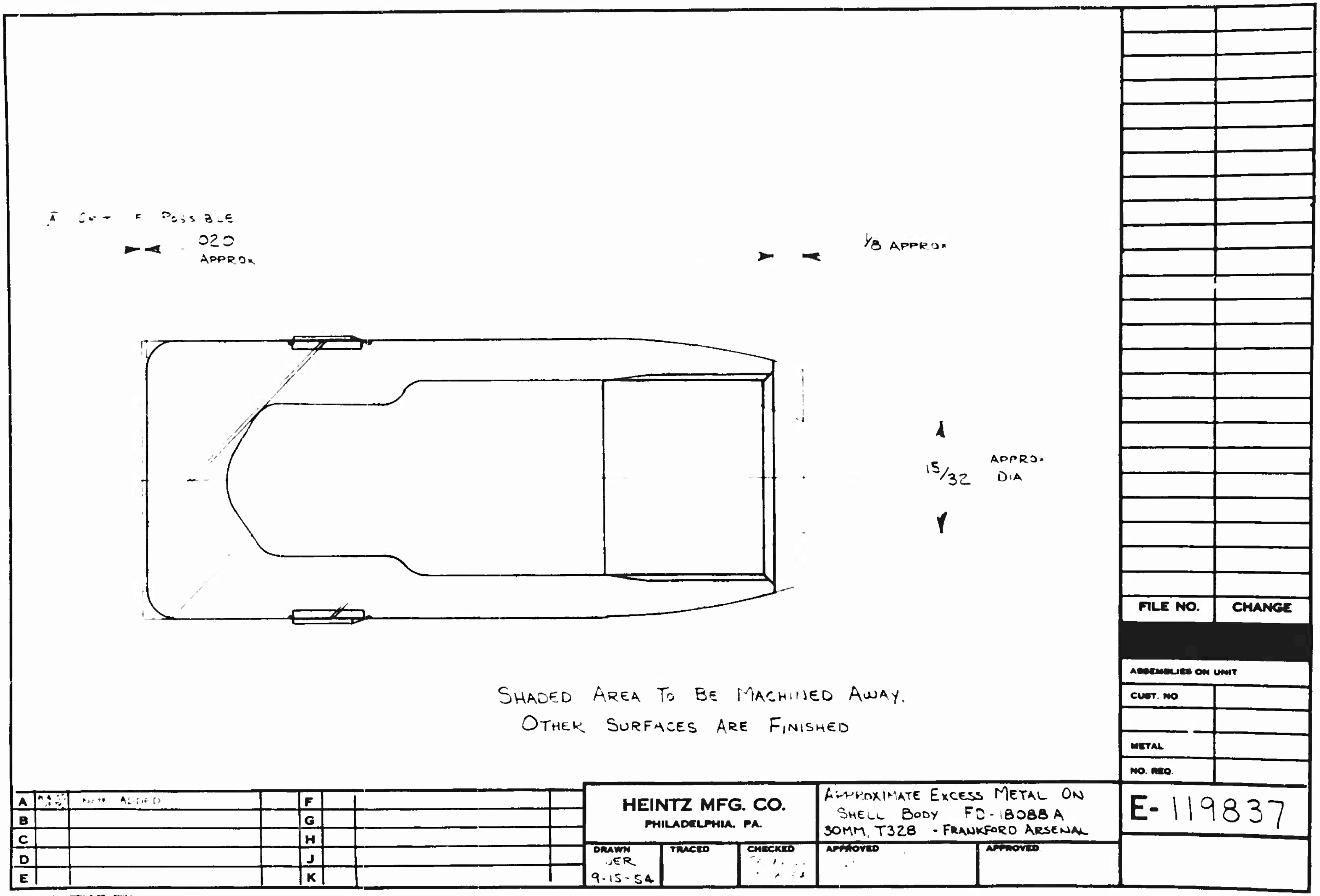
MACHINING AND FINISHING OPERATIONS

These operations to be described hereafter were performed by Pantex Manufacturing Company, Pawtucket, Rhode Island, on high production machine tooling.

The operations were as follows:

1. Rough face and drill
2. Finish face, drill and ream
3. Machine and knurl band seat and machine band groove
4. Wash
5. Tap the .8750-20-UNEF-28 thread
6. Wash
7. Swage band
8. Machine band
9. Stencil
10. Phosphatize
11. Paint
12. Pack

A sketch illustrating the cold formed blanks and indicating the metal to be removed is shown on the following page.



020
APPROX
1/8 APPROX
15/32
APPRO.
DIA
SHADED AREA TO BE MACHINED AWAY.
OTHER SURFACES ARE FINISHED
FILE NO.
CHANGE
ASSEMBLIES ON UNIT
CUST. NO
METAL
NO. REQ.
HEINTZ MFG. CO.
PHILADELPHIA, PA.
APPROXIMATE EXCESS METAL ON
SHELL BODY FD-18088A
30MM, T328 - FRANKFORD ARSENAL
E-119837
DRAWN
JER
9-15-54
TRACED
CHECKED
APPROVED
APPROVED

PROJECTILE, TARGET PRACTICE, 30MM, T328

MACHINING AND FINISHING OPERATIONS (Cont.)

1. ROUGH FACE AND DRILL

The open end of the cold formed blank was faced and the inside diameter in the area to be threaded was machined on a 1-5/8" New Britain Gridley six spindle automatic chucking machine. MOR-FILM, a soluble oil manufactured by L R Kerns Company, Chicago, Illinois, mixed with water in the ratio of 20:1 was used as a coolant.

The setup data for this operation is shown below in tabular form.

Machine:	1-5/8 New Britain Gridley	Spindle Gears:	45/87
Operation:	Drill & Face	Feed Gears:	47/85
Steel Spec:	1021	Tool Slide Cam Rise:	3/4
Collet Size:	1-3/16	Lower Front Forming Slide:	7/32
SSFPM:	111	Motor:	15 HP, 220 V, 3 phase, 60 cycle
Spindle RPM:	435		
Cycle:	19		
Hourly Prod:	185		

POS	TOOL SLIDE OPERATION	POS	CROSS SLIDE OPERATIONS
1		1	Face to length 2.770-2.780 form tool holder (std)
2	Drill using st'd 5/8 three lip stub drill	2	
3	Drill using st'd 11/16 three lip stub drill	3	
4		4	
5		5	
6	Insert shell using st'd auxiliary operated inserter	6	Mount st'd gravity feed magazine in upper front forming slide.

2. FINISH FACE, DRILL AND REAM

The pieces were next chucked in a 1-1/2" eight spindle Conematic and the above operations were performed.

The types of tools, tool position, speeds and feeds, etc., are shown below. Drawings illustrating all but standard tools are found on the pages immediately following this text.

Machine:	1-1/2 x 8 Conematic Chucker Serial #3319WW	Spindle Gears:	33/39
		Feed Gears:	34/44
		Tool Slide Cam Rise:	3/4
Operation:	Face, Drill, Ream	Front Cross Slide Cam Rise:	1/4
Steel Spec:	1021		
Collet Size:	1-3/16	Rear Cross Slide Cam Rise:	0
SSFPM:	92		
Spindle RPM:	361	Aux Cam Pos 6 Rise:	11/16
Cycle:	26		
Hourly Prod:	135		

POS	TOOL SLIDE OPERATIONS	POS	CROSS SLIDE OPERATIONS
1	Drill using st'd 25/32 three lip stub drill	1	
2	Drill using st'd 13/16 three lip stub drill	2	
3		3	Face to 2.720-2.725 length using T-158-T-5 tool in T-158-T-11 tool holder
4	Ream minor pitch diameter using st'd 53/64 dia. (ground undersize to .823 dia.) 8 flute reamer	4	
5	Chamfer using st'd 1" dia. center drill	5	

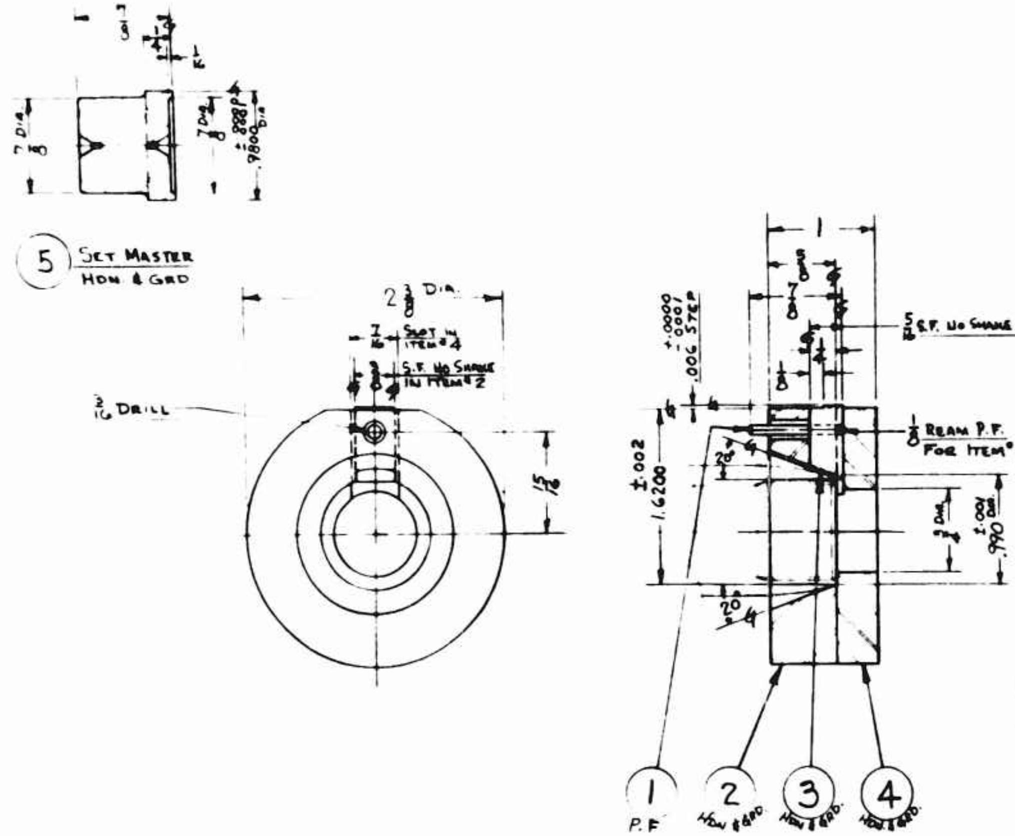
FINISH FACE, DRILL AND REAM (Cont.)

POS	TOOL SLIDE OPERATIONS	POS	CROSS SLIDE OPERATIONS
6	Ream front of .810 dia. cavity using st'd 13/16 dia. 8 flute reamer	6	
7	Insert shell using st'd auxiliary operated inserter	7	Mount st'd gravity feed magazine
8		8	

The coolant was the E F Houghton Company's Antisep All Purpose Base mixed with water in the ratio of 20:1.

This machine was powered by a 25 HP, 220 volt, 60 cycle, 3 phase, 1750 RPM motor.

The tools are shown on drawings on the pages immediately following this text.



LIST OF MATERIALS

ITEM No.	QUAN OF ROUGH Pcs.	QUAN OF FIN. Pcs.	ROUGH SIZE
1	1	1	DRILL ROD. $\frac{1}{8}$ DIA. X 1 LG.
2	1	1	#4 T.S. 2 1/2 DIA. X 1 LG.
3	1	1	DRILL ROD 1/2 SQ X 1 LG
4	1	1	#4 T.S. 2 1/2 DIA. X 1/2 LG.
5	1	1	#4 T.S 1 1/8 DIA. X 1 LG.

MARK TOOL No, Pc. No & 30MM FA
BREAK ALL UNNECESSARY SHARP EDGES

FRACTIONAL TOLERANCE	±.010
DECIMAL TOLERANCE	±.001
ANGLES	±15 MIN.
UNLESS OTHERWISE SPECIFIED	

FILE NO.	CHANGE

ASSEMBLIES ON UNIT

CUST. No 36	108103
S.O.	E-4016-19
METAL	
MO. REQ. No	47290

A		F	
B		G	
C		H	
D		J	
E		K	

HEINTZ MFG. CO.
PHILADELPHIA, PA.

GAGE TO CHECK .980 +.000 -.006 DIA.
30MM T328
FRANKFORD ARSENAL

DRAWN	TRACED	CHECKED	APPROVED	APPROVED
MD 3-9-55		HEL 3-9-55		HK 3-9-55

E-120473

J-15715

3. TURN AND KNURL BAND SEAT AND FORM BAND GROOVE AND 1/8 RADIUS ON BOTTOM OF SHELL

A 1-1/2" eight spindle Conematic chucking machine was used for these operations. The necessary machine data as well as tool position and type are as follows:

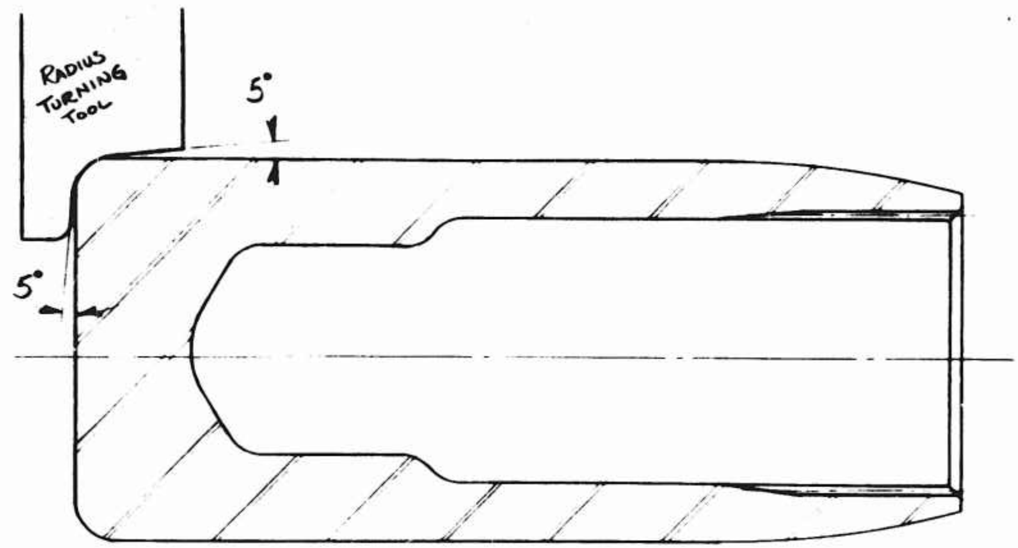
Machine:	1-1/2 x 8 Conematic Chucker, Serial #3319WW	Spindle Gears:	33/39
Operation:	Form band seat, groove, incl. knurl & form 1/8 radius on back	Feed Gears:	34/44
Steel Spec:	1021	Tool Slide Cam Rise:	1/2
Collet Size:	1-3/16	Front Cross Slide Cam Rise:	5/32
SSFPM:	110	Rear Cross Slide Cam Rise:	0
Spindle RPM:	361		
Cycle:	26		
Hourly Prod:	135		

POS	TOOL SLIDE OPERATIONS	POS	CROSS SLIDE OPERATIONS
1		1	
2		2	Form 1/8 radius on back using dovetail form tool in st'd 39-3 slitter form tool holder
3		3	Form band seat groove (partial) using T-158-T-5 tool in T-158-T-11 tool holder
4		4	Form 15^{o} band seat groove undercut using T-312E2-T-19 tool in M95-T-37 tool holder
5	Mount roll support using CX-15323 st'd tool holder	5	Knurl band seat with st'd 25P Reed knurling tool in M99-T-29 knurl holder

TURN AND KNURL BAND SEAT AND FORM BAND GROOVE AND 1/8 RADIUS ON BOTTOM OF SHELL (Cont.)

POS	TOOL SLIDE OPERATIONS	POS	CROSS SLIDE OPERATIONS
6		6	
7	Insert shell using st'd auxiliary operated work inserter	7	Mount st'd gravity feed magazine
8		8	

Houghton's Antisep All Purpose Base, mixed with water in the ratio of 20:1, was the coolant.



HEINTZ MFG. CO.
PHILADELPHIA, PA.

LAYOUT OF TURNING 1/8 RAD. ON BASE OF 30MM, T328 SHELL
FRANKFORD ARSENAL

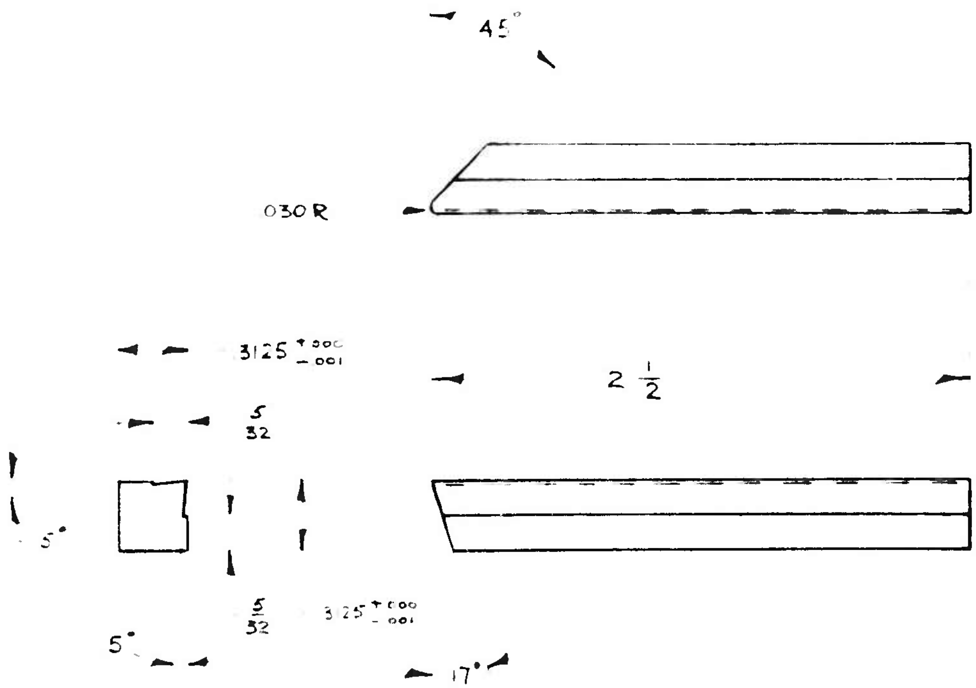
DRAWN	TRACED	CHECKED	APPROVED	APPROVED
JER 3-17-55		J.E.R. 3-18-55		

FILE NO. | CHANGE

ASSEMBLIES ON UNIT
CUST. NO
METAL
NO. REQ.

E-

SK# 10954



MAKE OF STD. 5/16 SQ HIGH SPEED STEEL

FOR MACHINING
30 MM SHELL

HEINTZ MFG. CO.
PHILADELPHIA, PA.

UNDERCUTTING TOOL
PANTEX MFG. CO. CENTRAL FALLS R.I.

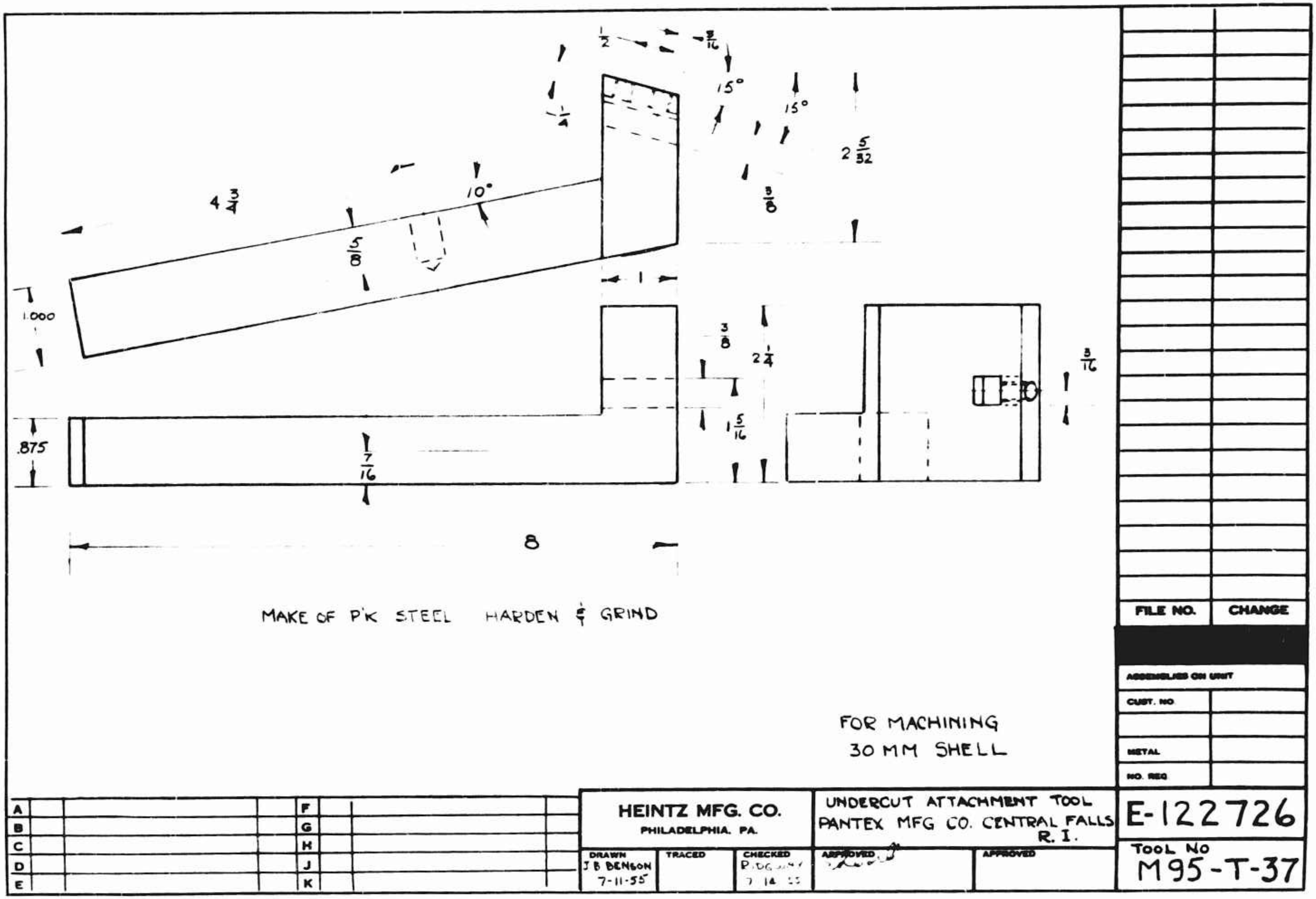
DRAWN J.B. BENSON 7-12-55
TRACED
CHECKED
APPROVED
APPROVED

FILE NO. | CHANGE

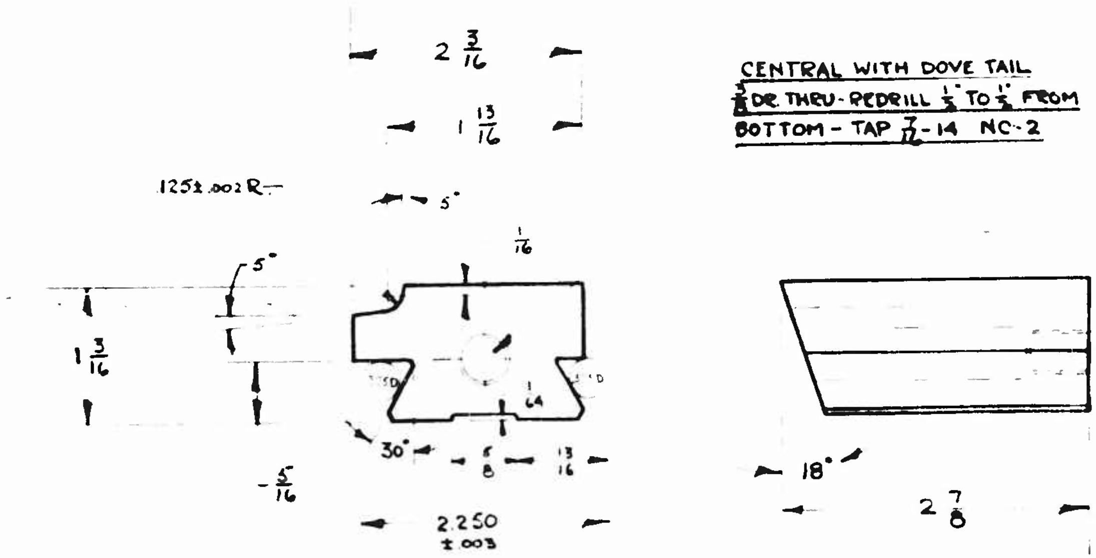
ASSEMBLIES ON UNIT
CUST. NO
METAL
NO. REQ

E-122724

TOOL No. T312E2-T-19



1/2
3/16
1/4
15°
15°
2 5/32
3/8
4 3/4
10°
5/8
1
1.000
3/8
2 1/4
3/16
1 5/16
.875
7/16
8
MAKE OF P'K STEEL HARDEN & GRIND
FOR MACHINING
30 MM SHELL
FILE NO.
CHANGE
ASSEMBLIES ON UNIT
CUST. NO.
METAL
NO. REQ
A
B
C
D
E
F
G
H
J
K
HEINTZ MFG. CO.
PHILADELPHIA PA.
UNDERCUT ATTACHMENT TOOL
PANTEX MFG CO. CENTRAL FALLS R. I.
E-122726
DRAWN
J B BENSON
7-11-55
TRACED
CHECKED
APPROVED
APPROVED
TOOL NO
M95-T-37



CENTRAL WITH DOVE TAIL
3/8 DR. THRU - REDRILL 1/2" TO 1/2" FROM
BOTTOM - TAP 7/16-14 NC-2

MAKE OF H.S.S. - M3 - TYPE-2 - HARDEN Rc 63-65 & GRIND ALL OVER

FILE NO.	CHANGE

ASSEMBLIES ON UNIT

CUST NO

METAL

NO REQ

A B C D E F G H J K

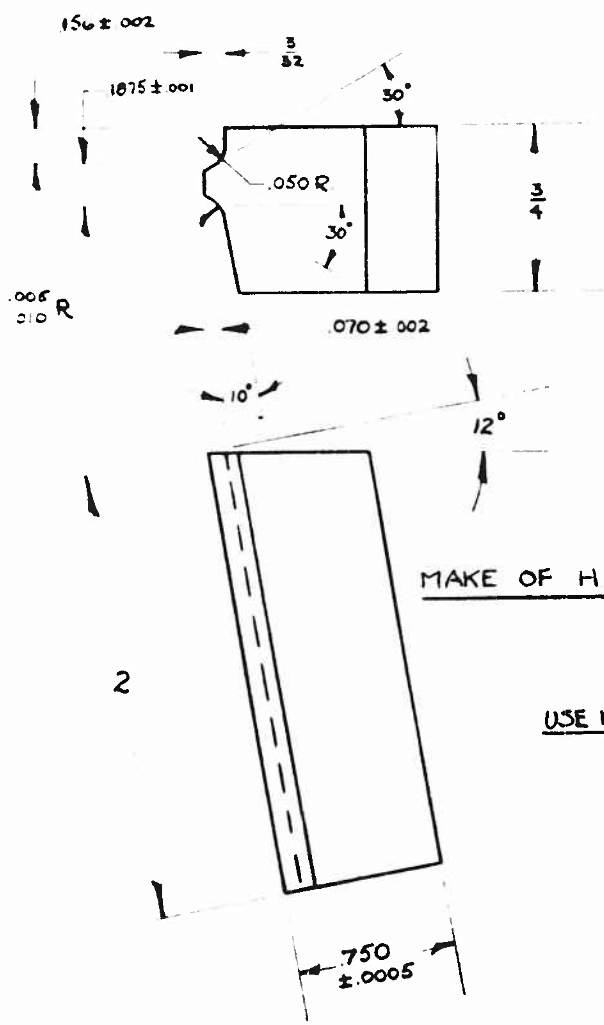
HEINTZ MFG. CO.
PHILADELPHIA, PA.

RADIUS TOOL USED BY PANTEX MFG. CO. CENTRAL FALLS R.I.

DRAWN	TRACED	CHECKED	APPROVED	APPROVED
J.B. BENSON 7-11-55		RIDGWAY 7-14-55		

E-122728

TOOL No. T328-T-2



MAKE OF H.S.S. - HARDEN Rc 63-65 & GRIND

USE IN HOLDER - M99-T-27

FOR MACHINING 30 MM SHELL

FILE NO.	CHANGE
ASSEMBLIES ON UNIT	
CUST. NO	
METAL	
NO. REQ.	

A			F	
B			G	
C			H	
D			J	
E			K	

HEINTZ MFG. CO. PHILADELPHIA, PA.		3/4" BREAK DOWN TOOL USED BY PANTEK MFG. CO. CENTRAL FALLS R.I.		E-122729	
DRAWN S.B. BENSON 7-11-55	TRACED	CHECKED RIDGWAY 7-14-55	APPROVED	APPROVED	TOOL NO. M-99-T-29

4. WASH

The machine used was a Blakeslee Metal Parts Washer of a single stage conveyor type, serial No 1138, manufactured by G S Blakeslee & Company of Chicago, Illinois.

The pieces were placed open end down in welded wire baskets which held fifty (50) pieces each. As the pieces were carried through the machine by the conveyor they were sprayed with an emulsion cleaner and a rust inhibitor.

The chemicals used were NAMUL (emulsion cleaner) and SR-12 (rust inhibitor) which were manufactured by the Angler Chemical Company, Norton, Massachusetts.

The NAMUL was mixed in the ratio of one (1) gallon to one hundred seventy-five (175) gallons of water and the SR-12 was used at the ratio of four (4) ounces to one hundred seventy-five (175) gallons of water. The temperature of the spray was maintained at 175° F.

5. TAP 3/4"-20 THREAD

A Kaufman tapping machine, Serial #10-188, with a capacity of 5/8" to 1-1/8", manufactured by the L J Kaufman Manufacturing Company, Manitowok, Wisconsin, was used. The machine setup is listed below:

1. Motor: 3HP, 220 volts, 3 phase, 60 cycle, 1725 RPM
2. Coolant: Trifalex (undiluted)
3. Production Rate: 200 pcs/hr.
4. Spindle Speed: 400 RPM
5. Lead Screw: 20 pitch, left hand

The operator placed two shell in the loading position of an eight station rotary table. The table then indexed and tapped two bodies simultaneously. While the machine operated, the operator removed two finished shell and replaced them with two new ones. The cycle was then repeated. An undiluted cutting oil manufactured by Trifalex Corporation of New York City was applied by brush to the area to be tapped.

6. <u>WASH</u>

This operation was identical to operation #4.

7. SWAGE ROTATING BAND

A size 0 swaging machine manufactured by West Tire Setter Company, Rochester, New York, was used for this operation.

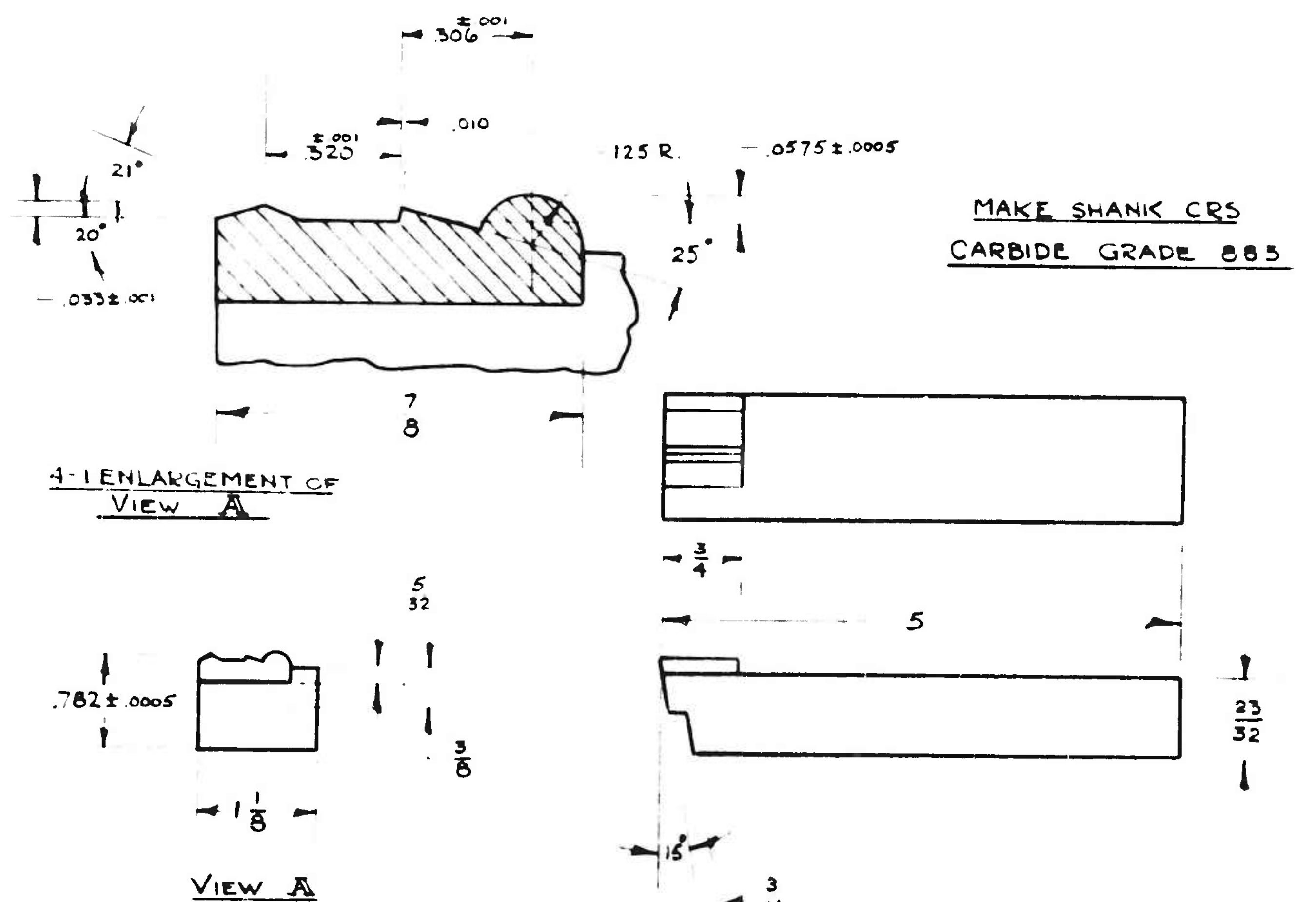
The shell was placed in the machine and its three jaws closed on the band, squeezed it into the band seat and around the knurls. A plug which closely fit the inside diameter was inserted in the shell to prevent collapse of the wall.

8. MACHINE BAND

The band was formed on a Rapiduction Lathe type 601WD, manufactured by the Oster Manufacturing Company, Cleveland, Ohio.

The setup chart for this operation is shown below and tool drawings are found on the pages immediately following this text.

Collet Size:	1-3/16
Form Tool:	T-158-T-46
Tool Holder:	M-99-T-69
Spindle Speed:	1850 RPM
Coolant:	Houton Antisep 20:1
Manual Operation	



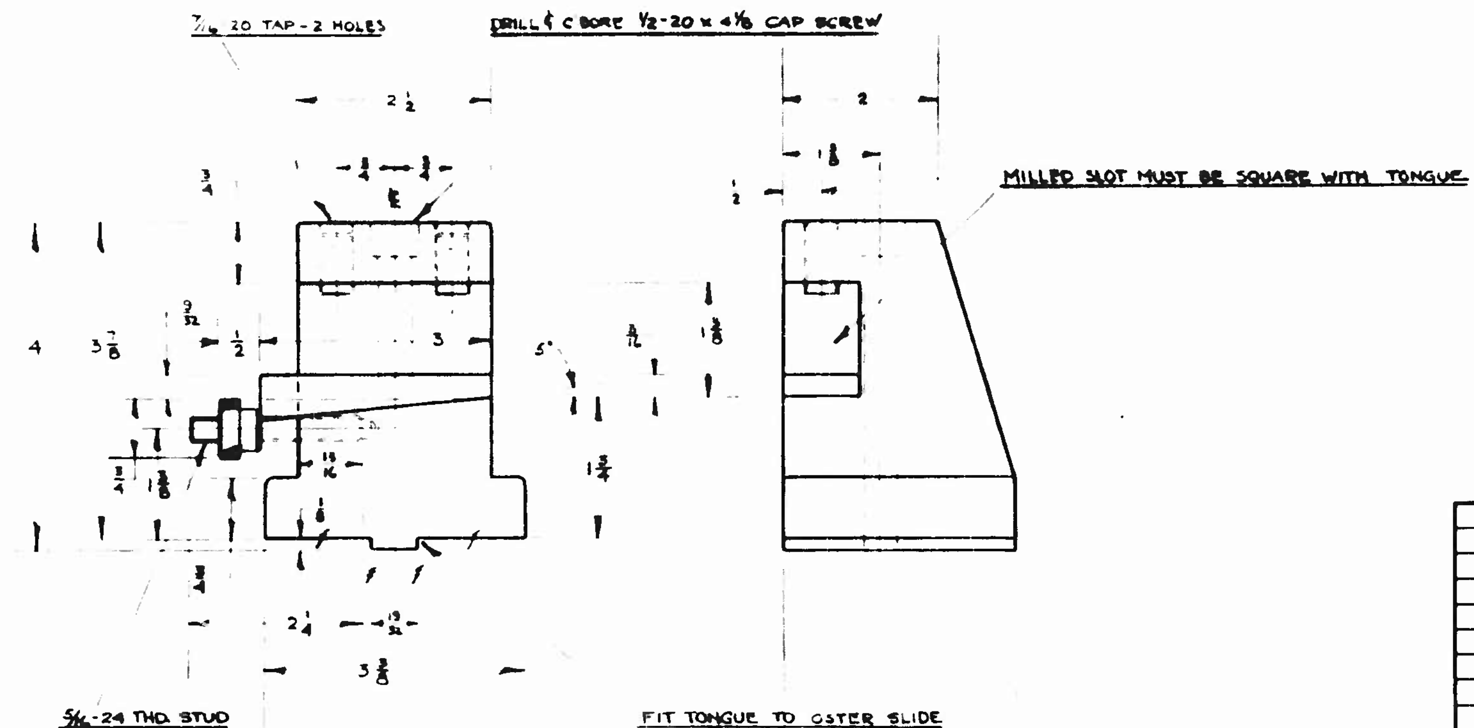
MAKE SHANK CRS

CARBIDE GRADE 883

FOR MACHINING 30 MM SHELL

HEINTZ MFG. CO. PHILADELPHIA, PA.	FORM TOOL USED BY PANTEX MFG. CO. CENTRAL FALLS R.I.	E-122723
DRAWN J. B. BENSON 7-12-56 / TRACED / CHECKED	APPROVED / APPROVED	TOOL NO. T-158-T-46

FILE NO.	CHANGE
ASSEMBLIES ON UNIT	
CUST NO	
METAL	
NO REQ	



FOR MACHINING
30 MM SHELL

HEINTZ MFG. CO.
PHILADELPHIA, PA

TOOL POST USED BY
PANTEX MFG CO CENTRAL FALLS R.I

D-122721

TOOL NO
M99-T-69

9. STENCIL

A marking machine made by Noble & Westbrook Manufacturing Company, East Hartford, Connecticut, was used to stencil this shell.

Standard 1/16" high type was used to stencil at the rate of fifteen hundred (1500) pieces per hour.

The pieces were placed on the periphery of a large table which revolved slowly. Mounted on top of this table and on the same axis was a wheel of slightly smaller diameter which revolved at a slightly higher RPM than the table. As the table carried the pieces to the stationary stencil the wheel forced the piece against it. The stencilled pieces were automatically ejected from the machine.

10. PHOSPHATIZE FOR PAINT

The machine for the cleaning cycle used for this operation was a Blakeslee Metal Parts Washer of a single stage conveyor type, manufactured by G S Blakeslee & Company, Chicago, Illinois. The shell bodies were placed mouth down in welded wire baskets which held fifty (50) pieces each. As the pieces were carried through the machine by the conveyor they were sprayed with the cleaner.

The remaining operations were done by dipping the pieces in tanks which contained the various solutions. The baskets were moved from tank to tank using a one (1) ton Budgit Hoist.

The chemical cycle was as follows and conformed to MIL-C-490. Two thousand (2,000) pieces an hour were processed.

1. Clean

Machine:	Blakeslee Metal Parts Washer
Chemical:	#420A Cleaner
Manufacturer:	Angler Chemical Company, Norton, Massachusetts
Composition:	8 lbs. of cleaner to 175 gal. of water
Temperature:	160° F.
Time:	4 min.
Type of Application:	Spray

PHOSPHATIZE FOR FAINT (Cont.)

2. Rinse

Machine:	200 gallon tank
Chemical:	None
Composition:	None (water)
Temperature:	180° F.
Time:	1 min.
Method of Application:	Dip

3. Phosphate Coat

Machine:	250 gallon tank
Chemical:	Matabond #14
Manufacturer:	International Rust Proof Company of Cleveland, Ohio
Composition:	32 point bath
Temperature:	200° F.
Time:	8 min.
Method of Application:	Dip

4. Rinse

Machine:	200 gallon tank overflowing
Chemical:	None
Composition:	Water
Temperature:	205° F.
Time:	1 min.
Method of Application:	Dip

PHOSPHATIZE FOR PAINT (Cont.)

5. Chromic Acid Dip

Machine:	200 gallon tank
Chemical:	D & I rinse
Manufacturer:	Doe & Ingalls, Inc., Everett, Mass.
Composition:	1 pint
Temperature:	210° F.
Time:	2 min.
Method of Application:	Dip

11. PAINT

Black lusterless enamel conforming to specification MIL-E-10687 was applied to the shell bodies by a Paasche air finishing machine, manufactured by Paasche Air Brush Company, Chicago, Illinois. This was a conveyor machine type 236. The conveyor had seventy-two spindles and the entire machine was capacle of painting fifteen hundred (1500) shell per hour. The spray guns and pressure tanks were made by the deVilbiss Company of Toledo, Ohio.

The pieces were placed vertically with the open end up on the conveyor spindles and were carried around to the painting location. The shell started to rotate just before they reached the spray gun. Two spray guns were used. One was located above the shell and directed the paint spray along a line making a ten degree (10°) angle with the horizontal. The second gun was located under the piece and sprayed upward at a thirty degree (30°) angle. The pieces then passed through a drying tunnel which employed as a heat source fourteen (14) lamps which dissipated fourteen (14) Kilowatts.

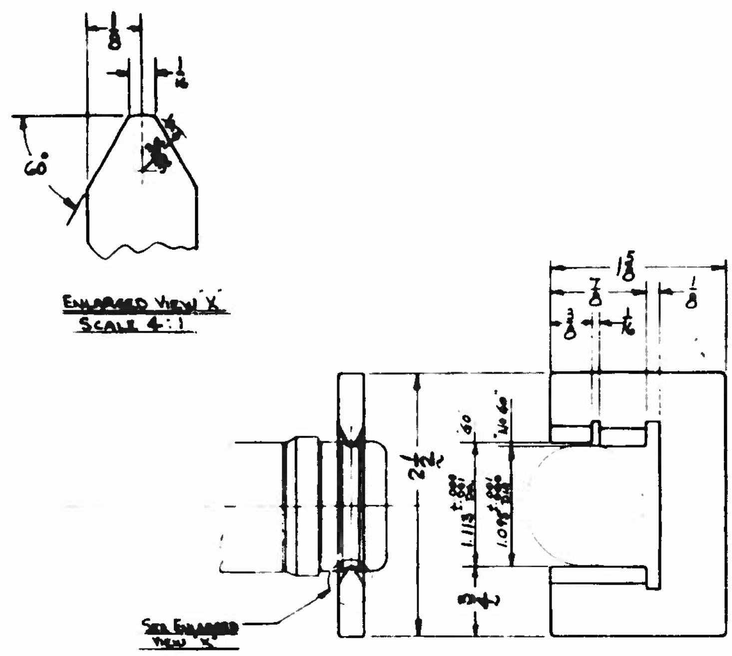
PROJECTILE, TARGET PRACTICE, 30MM, T328

INSPECTION

The following list of gages was used to check this shell.

1.	Length gage (press)	J-15146
2.	Thread gage	J-15736
3.	Crimp groove check	J-15709
4.	O.D. of band 1.228" go	J-15710
5.	Progressive snap gage for band O.D.	J-15711
6.	Overall length 2.74"	J-15713
7.	.980" Nose diameter	J-15715
8.	.810-.825" plug gage	J-15719
9.	.654-.664" plug gage	J-15720
10.	.8209-.8287" plug gage	J-15737

All of these gages are standard with the exception of items #1 and 3. These gages are shown on Dwg #D-121116 and E-120470 on the following pages.



GAGE STOCK 1/4 x 2 1/2 x 1 5/8
HDN. & GRD.

MARK TOOL No & Pc No. & 30MM FA
BREAK ALL UNNECESSARY SHARP EDGES

±.010
±.001
±1/2°

...SPECIFIED

FILE NO.	CHANGE

ASSEMBLIES ON UNIT

CUST. NO. Pc.	108103
S.O.	E-4016-15
METAL	
MA. REQ. No.	47285

HEINTZ MFG. CO.
PHILADELPHIA, PA.

GAGE TO CHECK .030 $^{+.009}$ DIA. CRIMPING GROOVE
30MM T306 E10 & 30MM T328
FRANKFORD ARSENAL

DRAWN	TRACED	CHECKED	APPROVED	APPROVED
ND 3-7-55		JDL 3-7-55	T. K. 3-7-55	

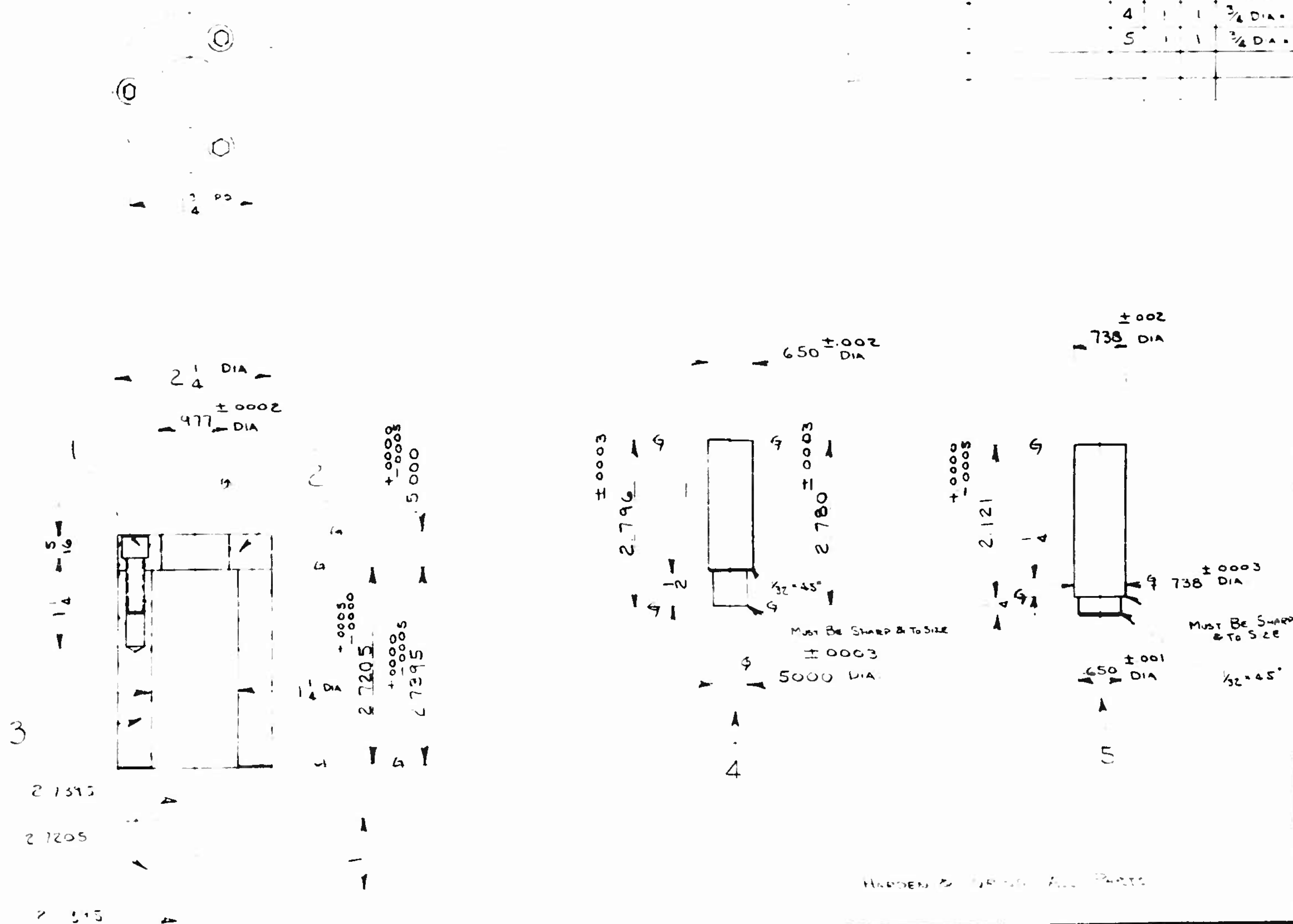
E-120470

J-15709

A		F	
B		G	
C		H	
D		J	
E		K	

BILL OF MATERIALS

NOTE	DETAIL NO.				ROUGH SIZE	
			3	3	4 DIA × 3/4 LG	SMART CAP SCREW HEAD
	2	1	1		2 1/2 DIA × 1 LG	# 1 TS
	3	1	1		2 1/2 DIA × 3 1/4 LG	# 1 TS
	4	1	1		3/4 DIA × 3 LG	# 1 TS
	5	1	1		3/4 DIA × 3 LG	# 1 TS



HARDEN & GRIND ALL PARTS

FILE NO.	CHANGE

ASSEMBLED ON UNIT

CUST. NO	108103
SO E	4016-12
METAL	
NO REQ	46710

HEINTZ MFG. CO.
PHILADELPHIA, PA

LENGTH GAGE
FRANKFORD ARSENAL

DRAWN JER | TRACED | CHECKED | APPROVED | APPROVED

D-121116

JIG NO J-15146

PROJECTILE, TARGET PRACTICE, 30MM, T328

PACK

The pieces were packed according to specification MIL-P-10025A.

The box was made from 1/8" double faced corrugated cardboard and was 12-3/4" long x 6-3/8" wide x 9-1/4" deep and held one hundred (100) shell bodies in two (2) layers of fifty (50) each. The individual bodies were placed inside the spaces created by a 1/32" thick smooth cardboard separator. This separator was of the egg crate variety and formed pockets to hold five (5) shell along the width and ten (10) shell along the length of the box. A flat piece of 1/8" double face corrugated cardboard was used to separate the layers.

PROJECTILE, TARGET PRACTICE, 30MM, T328

METALLURCICAL DATA AND DISCUSSION

This shell body, in common with the other three previously discussed, had mechanical property requirements of 90,000 psi minimum yield strength and an elongation of 10%.

The type steel, the metallurgical thinking, and procedures were identical to those employed on the T304 and T241 shell bodies. The only differences peculiar to this shell were the reduction in area and the resultant change in the stress relief temperature to 700° F.

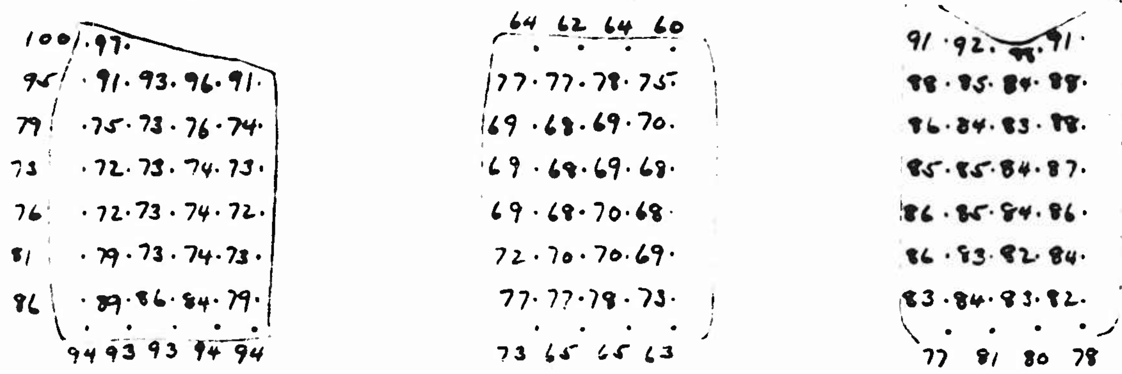
The mechanical properties obtained using a 1/2" flat specimen are listed below:

Specimen	Tensile Strength	Yld. Str. (.1% Off.)	Elong. in 1/2"	Hardness Range
1-2	102,750	97,700	11.0%	99-104
2-2	103,300	97,600	12.5%	99-104

Hardness patterns illustrating the effects of cold working and both process and stress relief anneals appear on the page following this text.

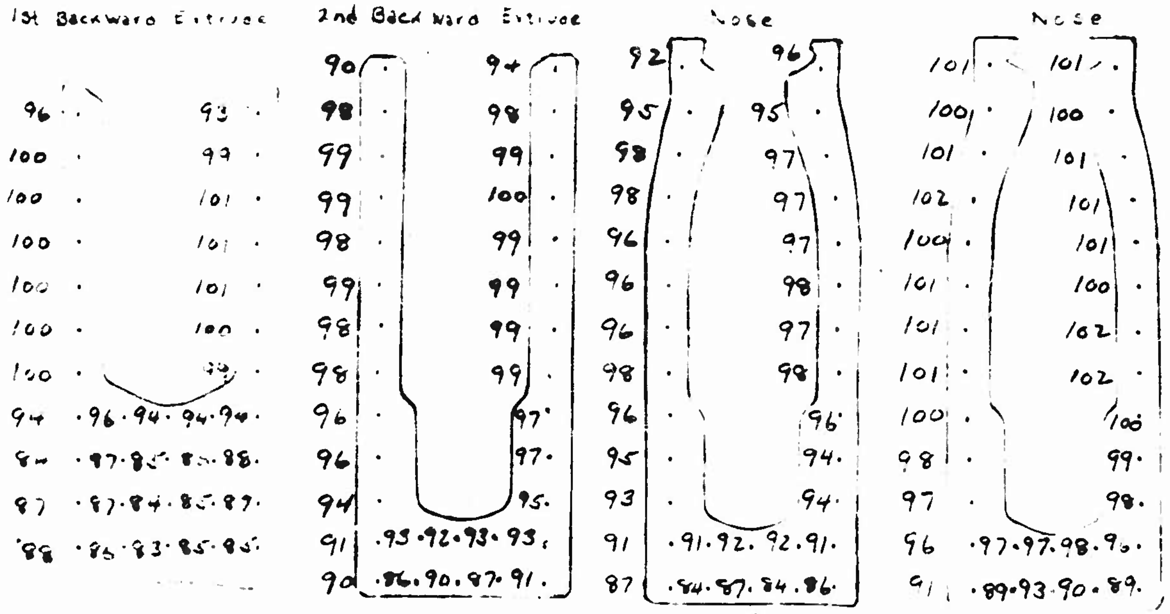
BY H.A.D. DATE 4/7/55 SUBJECT Hardness Survey SHEET NO. .... OF ....
CHKD. BY .... DATE .... 30 MM T 332 Steel 1021 JOB NO. V-40.36
Frankford Arsenal Scale RB HL" 49N 294

Billet | Billet | Size



Unannealed | 1250°F Anneal, 1½ hours at heat, Lindberg Furnace | As hit

1st Backward Extrude | 2nd Backward Extrude | Nose | Nose



As hit | As hit | Before Stress Relieve | After Stress Relieve (700° for 2 hours)

APPENDIX

Chemical Data:

All cold forming operations of the severity described in this report require a lubricant that will withstand the extreme pressures. The importance of this lubricant cannot be over-emphasized and unless it is carefully controlled as outlined below, work pieces will be severely galled and eccentric.

Surface Treatment - Procedure and Controls

1. Alkaline Cleaner
   Fosclean C-4, 6 oz./gal., 200-210° F., 5 minutes
2. Cold, overflowing water rinse
3. Sulfuric Acid Pickle
   12% H_2SO_4 by weight, 170° F., 4-5 minutes
4. Cold, overflowing water rinse
5. Hot, overflowing water rinse (160° F.)
6. Foscoat
   35 points, 180-185° F., 7 minutes
7. Cold, overflowing water rinse
8. Final hot rinse
   Fosrinse R-1, 0.1%, 160° F., 30-60 seconds
9. Lubrication
   Foslube L-19, 2.5% solids, 130-150° F., 3 minutes

Process:	Foscoat
Operation:	Alkaline Cleaning
Material:	Fosclean C-4, PennSalt Mfg. Co.

Tank Capacity:	361 gallons
Concentration:	6 oz. /gallon
Charge:	135 lbs. Fosclean C-4
Operating Instructions:	Immerse for 5 minutes at 200-210° F. Bath to be air agitated

Process:	Foscoat
Operation:	Pickling
Material:	Sulfuric Acid, 66° Baume, Sp. gr. 1.835
Tank Capacity:	363 gallons
Concentration:	10-12% by wt. 106-130 gms. H_2SO_4/liter
Charge:	26 gallons (2 carboys) Sulfuric Acid
Operating Instructions:	Immerse for 4-5 minutes at 170° F. Iron content should not exceed 4-5%

Process:	Foscoat
Operation:	Foscoat
Material:	Foscoat A, Z, AS, SG, PennSalt Mfg. Co.
Tank Capacity:	409 gallons

35 point bath

10.40 gallons (143 lbs.) Foscoat Z

2.75 gallons (30.7 lbs.) Foscoat A

8.20 lbs. Foscoat SG

Alternative

7.26 gallons (92 lbs.) Foscoat AZ

6.05 gallons (84 lbs.) Foscoat Z

8.02 lbs. Foscoat SG

Operating Instructions:	Immerse for 7 minutes at 180-185° F. Temperature must be regulated so that introduction of work load does not reduce temperature below 180° F. Work must be racked to permit escape of gas.

Process:	Foscoat
Operation:	Final Hot Rinse
Material:	Fosrinse R-1, PennSalt Mfg. Co.
Tank Capacity:	560 gallons
Concentration:	0.1% by weight
Charge:	4.7 lbs. Fosrinse R-1
Operating Instructions:	30-60 seconds at 140-160° F.

Process:	Foscoat
Operation:	Lubrication
Material:	Foslube L-19, PennSalt Mfg. Co.
Tank Capacity:	361 gallons
Concentration:	10% by wt. of the product (2.5% fat content)
Charge:	300 lbs. Foslube L-19
Operating Instructions:	3 minutes at 130-150° F.

SUGGESTED PRESS EQUIPMENT TO MAKE SMALL CALIBER PROJECTILES FROM 20MM to 40MM

While as earlier noted, only five light presses--the heaviest being 250 tons at most--would be required to make the simpler 30mm projectiles, a desirable lineup of optimum utility is suggested below.

OPERATION	TONNAGE & DISTANCE UP FROM BOTTOM OF STROKE	SHUT HEIGHT ON TOP OF BOLSTER STROKE DOWN ADJ. UP	KNOCKOUT (See Note #4)	STROKE
SHEAR	100 T, 1" up	14"	No	6"
FORMING	500 T, 1" up	30"	Yes	16"
FORMING	400 T, 2" up	30"	Yes	16"
FORMING	400 T, 2" up	30"	Yes	16"
FORMING	200 T, 2" up	30"	Yes	16"
FORMING	200 T, 2" up	30"	Yes	16"
FORMING	100 T, 1" up	30"	Yes	16"

NOTES:

1. All Bed Areas: 30" x 30"
2. All Presses rated at 50 strokes per minute except the Shearing Press which should be rated at 125 strokes per minute
3. All Presses to have automatic feeding device
4. Knockout to have adjustable travel - 0" to 6" and 10% of rated press tonnage
5. All press rams to have 3" adjustment
6. Knockout Stroke Cycle:
   a. Ram top dead center - Knockout up
   b. Ram 90° forward - Knockout down
   c. Knockout dwell down until ram is 5" up on return stroke
   d. Ram 60° before top dead center - Knockout up
   e. Knockout raised and dwelling for top 60° of ram cycle

APPENDIX (Cont.)

MATERIAL SPECIFICATIONS

Carbon or alloy steel for the production of these shell should be ordered as "Hot Rolled Bar Stock" to meet Federal Specification QQ-S-633. Knowing the end use of the steel and the process to be used, the fabricator and the steel mill can jointly determine specific requirements and precautions necessary to produce steel that will produce satisfactory finished pieces (and within the general AISI requirements for projectile quality steel).

Certain requirements have been developed which can serve as starting points in any such discussion. These points will be described briefly in the following paragraphs.

The steel should be bought in the "as-rolled" condition. It has been found that the lower carbon steels can be sized or backward extruded in the "as-rolled" condition.

Chemistry restrictions need not be any more rigid than called for under this Federal Specification with the possible exception of silicon. Our experience has indicated that a "Fully Aluminum Killed" steel is the best type to use for this work. In any event, it would be wise to limit the silicon content to .08 maximum.

Commercial tolerances for dimensions and reconditioning of bar stock are satisfactory.

The application of macroetch examination standards should be approached with caution. Certain obvious defects such as pipes, flakes, bursts, severe segregation, and deep surface defects are, of course, unacceptable. When it comes to various types of ingot patterns and segregation patterns, however, no clearly defined correlation with defects in finished pieces has been established. If such a correlation can be established, it should be negotiated with the steel mill.

Grain size should be 5 or finer (Ferritic).